GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[x] ORIGINAL [ ] REVISION NO. ______

Project No. A-3095 DATE 11/13/81

Project Director: Billy B. Wise CO ~~School~~/Lab ECSL/CCB

Sponsor: Newcomb & Boyd, Consulting Engineers

Type Agreement: Letter Agreement dated 10/22/81

Award Period: From 10/22/81 To ~~12/1/81~~ 12/30/82 (Performance) ______ (Reports)

Sponsor Amount: $10,000 Contracted through:

Cost Sharing: N/A GTRI/~~GIT~~

Title: Energy Monitoring & Control System (EMCS) Operator Training Manual and Course of Instruction

ADMINISTRATIVE DATA

OCA Contact Faith G. Costello

1) Sponsor Technical Contact:

See Adm. Contact

2) Sponsor Admin/Contractual Matters:

* Warren D. Shiver
Newcomb & Boyd
Consulting Engineers
Suite 200 Alpha Bldg.
Atlanta, GA 30318

Ph.: 352-3930

Defense Priority Rating: ______

Security Classification: ______

RESTRICTIONS

See Attached ______ Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with sponsor

COMMENTS:

Issued under Gov't prime #N62474-81-C-9405. Formal contract to be issued at a later date.

NOV 1981 RECEIVED Research Reports Office

COPIES TO:

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Project File
Other ______

FORM OCA 4:781

2-SR39/86

GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION SHEET

Date: March 29, 1983

Project Title: Energy Monitoring & Control System (EMCS) Operator Training Manual and Course of Instruction

Project No: A-3095

Project Director: B. B. Wise

Sponsor: Newcomb & Boyd, Consulting Engineers

Effective Termination Date: 12/31/82

Clearance of Accounting Charges: 1/31/83 (reports)

Grant/Contract Closeout Actions Remaining:

None

- [ ] Final Invoice ~~and Closing Documents~~
- [ ] Final Fiscal Report
- [x] Final Report of Inventions
- [x] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other ______

Assigned to: ECSL/CCB (~~School~~/Laboratory)

COPIES TO:

Administrative Coordinator	Research Security Services	EES Public Relations (2)
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A-3095

Georgia Institute of Technology

ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA 30332

November 19, 1981

Mr. Warren Shiver
Newcomb & Boyd
Consulting Engineers
Suite 200, Alpha Building
One Northside 75
Atlanta, Georgia 30318

SUBJECT: Deliverable No. 1, Letter Progress Report (A-3095)

REFERENCE: Letter Agreement dated October 22, 1981, EMCS Operator Training Manual and Course of Instruction

Dear Mr. Shiver:

This is the first of a series of progress reports addressing the status of the referenced contract. This report covers the period October 22, 1981 to November 30, 1981.

STATUS

Work during this initial period included detailed project schedule planning, data collection, and preparation of draft course development documents.

- The project schedule was refined and detailed to provide for well-coordinated efforts between Georgia Tech and Newcomb & Boyd. The agreed upon schedule is included as an enclosure to this report. Provided guidelines for training course goal development in accordance with Mager-Pipe technique.

- Investigation and data collection were conducted in the areas of EMCS operator job descriptions, operator manning at EMCS sites, and equipment specifications for an operator training device.

- In preparation for a work session with service representatives, wrote a guide briefing including draft documents on operator manning, EMCS operator job description, and the design of a training device for use in the course.

- Attended work session with service representatives, participated in discussion and information exchange, and assisted in preparation of meeting notes.

PLAN

Effort in the next month will be directed toward refining the scope and content of the training course. A field trip has been tentatively planned for this period to observe actual EMCS operating procedures at military facilities in the east coast area.

PROBLEM AREAS

None

FUNDING STATUS

Contract amount in Letter agreement to December 1, 1981	$10,000
Less dollars expended to date	9,447
Balance as of November 30, 1981	$ 553

Yours truly,

Billy B. Wise,
Project Director
Command and Control Programs
Electronics & Computer Systems
Laboratory

Approved:

H. Bennett Teates,
Head
Command and Control Programs
Electronics & Computer Systems
Laboratory

BBW/HBT:dar

Enclosure

EMCS OPERATOR TRAINING OVERALL SCHEDULE

DATE	EVENT
September 30, 1981	Notice to Proceed
February 17, 1982	Task "A" Due
March 19, 1982	Receive Comments on Task "A"
April 18, 1982	Submit Corrected Task "A" Reports
July 27, 1982	Submit Draft Training Manual
August 26, 1982	Receive Commends on Training Manual
August 26, 1982	Submit Draft Course of Instruction
September 25, 1982	Submit Corrected Training Manual
September 25, 1982	Receive Comments on Course of Instruction
October 25, 1982	Teach Course
November 30, 1982	Receive Comments on Course
December 30, 1982	Submit Corrected Course

A-3095

Georgia Institute of Technology

ENGINEERING EXPERIMENT STATION

ATLANTA, GEORGIA 30332

December 23, 1981

Mr. Warren Shiver
Newcomb & Boyd
Consulting Engineers
Suite 200, Alpha Building
One Northside 75
Atlanta, Georgia 30318

SUBJECT: Deliverable Number Two, Letter Progress Report (A-3095)

REFERENCE: Contract between GTRI and Newcomb & Boyd
EMCS Operator Training Manual and Course of Instruction

Dear Mr. Shiver:

This is the second of a series of reports addressing the status of the referenced contract. This report covers the period December 1 to December 30, 1981.

STATUS

Work during this period was devoted to collecting and evaluating training materials from various EMCS vendors, defining the form of a training device, and developing a rough course outline. EMCS site visits discussed in the last report were rescheduled for after the Christmas/New Years holiday period.

PLAN

Two trips, to visit four selected EMCS sites, are planned for January , to collect data on operator job content and system operating requirements and procedures. Work will continue on defining course content.

PROBLEM AREAS

None

FUNDING STATUS

Total Contract Amount	$77,537.00
less dollars expended to date	-14,384.35
BALANCE as of December 30, 1981	$63,152.65

Sincerely,

Billy B. Wise,
Project Director,
Command and Control Programs
Electronics & Computer Systems Laboratory

Approved:

for H. Bennett Teates,
Head, Command and Control Programs
Electronics & Computer Systems Laboratory

BBW/HBT:dar

A-3095

Georgia Institute of Technology
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA 30332

February 10, 1982

Mr. Warren Shiver
Newcomb & Boyd
Consulting Engineers
Suite 200, Alpha Building
One Northside 75
Atlanta, Georgia 30318

SUBJECT: Deliverable Number 4, Letter Progress Report (A-3095)

REFERENCE: Contract between GTRI and Newcomb & Boyd EMCS Operator Training Manual and Course of Instruction

Dear Mr. Shiver:

This is the third of a series of reports addressing the status of the referenced contract. This report covers the period January 1 to January 31, 1982.

STATUS

During this period site visits were conducted to Fort Eustis, U.S. Naval Academy, Camp LeJeune, and Charleston AFB. The purpose of these visits was to collect information on operator background and training, system operation schedules, operator duties, etc., to serve as input to the Task A report. Work continued on writing portions of the Task A report.

PLAN

Task A report inputs will be completed and submitted in accordance with the contract deliverable schedule. Following that, work will begin on implementing the submitted training course outline.

PROBLEM AREAS

None.

FUNDING STATUS

Total Contract Amount	$77,537.00
less dollars expended to date	-20,285.54
Balance as of January 31, 1982	$57,251.46

Sincerely,

Billy B. Wise,
Project Director
Command and Control Programs
Electronics & Computer Systems
Laboratory

Approved:

H. Bennett Teates,
Head, Command and Control Programs
Electronics & Computer Systems Laboratory

BBW/HBT:dar

A-3095

Georgia Institute of Technology
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA 30332

March 10, 1982

Mr. Warren Shiver
Newcomb & Boyd
Consulting Engineers
Suite 200, Alpha Building
One Northside 75
Atlanta, Georgia 30318

SUBJECT: Deliverable Number 5, Letter Progress Report (A-3095)

REFERENCE: Contract between GTRI and Newcomb & Boyd EMCS Operator Training Manual and Course of Instruction

Dear Mr. Shiver:

This is the fourth of a series of reports addressing the status of the referenced contract. This report covers the period February 1 to February 28, 1982.

STATUS

During this period, all deliverable items specified in the contract as inputs to the Task A report were provided to Newcomb & Boyd on schedule. Inputs provided included papers covering:

1. Qualifications, background and training required for a competent EMCS operator.

2. The need and requirements for a training device to be used in conjunction with the training course.

3. An outline for the proposed EMCS operator training course.

PLAN

Effort during the next reporting period will be devoted to providing necessary detail to materials to be covered during individual class sessions, and collecting presentation materials.

PROBLEM AREAS

None.

FUNDING STATUS

Total Contract Amount	$77,537.00
less dollars expended to date	-25,300.53
Balance on February 28,1982	$57,251.46

Sincerely,

Billy B. Wise,
Project Director
Command and Control Programs
Electronics & Computer Systems
Laboratory

Approved:

H. Bennett Teates,
Head, Command and Control Programs
Electronics & Computer Systems Laboratory

BBW/HBT:dar

A-3095

Georgia Institute of Technology

ENGINEERING EXPERIMENT STATION

ATLANTA, GEORGIA 30332

April 9, 1982

Mr. Warren Shiver
Newcomb & Boyd
Consulting Engineers
Suite 200, Alpha Building
One Northside 75
Atlanta, Georgia 30318

SUBJECT: Deliverable Number 6, Letter Progress Report (A-3095)

REFERENCE: Contract between GTRI and Newcomb & Boyd EMCS Operator Training Manual and Course of Instruction

Dear Mr. Shiver:

This is the fifth of a series of reports addressing the status of the referenced contract. This report covers the period March 1 to March 31, 1982.

STATUS

Work during this period was directed toward developing lesson requirements for sessions requiring use of the training device. This is in preparation for producing a trainer design that will support the course. Responsibilities for production of various session lesson guides have been assigned and work is proceeding on course development.

PLAN

Work will continue on course development. A meeting of Tri-Service EMCS participants is scheduled for mid-April, in which Georgia Tech personnel will participate.

PROBLEM AREAS

None.

FUNDING STATUS

Total Contract Amount	$77,537.00
less dollars expended to date	27,947.43
Balance as of 3/31/82	$49,589.57

NOTE: Last month's report showed an incorrect balance of $57,251.46. It should have read $52,236.47.

Sincerely,

Billy B. Wise
Project Director
Command and Control Programs
Electronics & Computer Systems
Laboratory

Approved:

H. Bennett Teates
Head, Command and Control Programs
Electronics & Computer Systems Laboratory

BBW/HBT:nr

A-3095

Georgia Institute of Technology
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA 30332

May 10, 1982

Mr. Warren Shiver
Newcomb & Boyd
Consulting Engineers
Suite 200, Alpha Building
One Northside 75
Atlanta, Georgia 30318

SUBJECT: Deliverable Number 7, April Letter Progress Report (A-3095)

REFERENCE: Contract between GTRI and Newcomb & Boyd EMCS Operator Training Manual and Course of Instruction

Dear Mr. Shiver:

This is the sixth of a series of reports addressing the status of the referenced contract. This report covers the period April 1 to April 30, 1982.

Status

Participated in a meeting of Tri-Service EMCS representatives on subject training course. Discussed course development and desired changes to Task A report. Submitted updated versions of report to Newcomb & Boyd on schedule. Continued work on course development, especially on those sessions requiring use of the training device.

Plan

Continue work on course development, aiming toward the next scheduled deliverable date in July.

Problem Areas

None

Funding Status

Total Contract Amount	$77,537.00
less dollars expended to date	32,394.78
Balance as of 4/30/82	$45,142.22

Sincerely,

Billy B. Wise,
Project Director
Command and Control Programs
Electronics & Computer Systems
Laboratory

Approved:

H. Bennett Teates
Head, Command and Control Programs
Electronics & Computer Systems Laboratory

BBW/HBT:dar

A 307

Georgia Institute of Technology

ENGINEERING EXPERIMENT STATION

ATLANTA, GEORGIA 30332

June 10, 1982

Mr. Warren Shiver
Newcomb & Boyd
Consulting Engineers
Suite 200, Alpha Building
One Northside 75
Atlanta, Georgia 30318

SUBJECT: Deliverable Number 8, May Letter Progress Report (A-3095)

REFERENCE: Contract between GTRI and Newcomb & Boyd EMCS Operator Training Manual and Course of Instruction

Dear Mr. Shiver:

This is the seventh of a series of reports addressing the status of the referenced contract. This report covers the period May 1 to May 31, 1982.

STATUS

Have completed sample lesson guide which is being used to develop all other lesson guides. Sessions on Introduction to EMCS are nearing completion. Provided draft copy of Training Device Functional Description to Newcomb & Boyd for information and comments.

PLAN

Continue work on course development, aiming toward the next scheduled deliverable data in July.

PROBLEM AREAS

None

FUNDING STATUS

Total Contract Amount	$77,537.00
less dollars expended to date	36,709.44
Balance as of 5/31/82	$40,827.56

Sincerely,

Billy B. Wise
Project Director,
Command and Control Programs
Electronics & Computer Systems
Laboratory

Approved:

H. Bennett Teates
Head, Command and Control Programs
Electronics & Computer Systems Laboratory

BBW:HBT/dar

A-3095

Georgia Institute of Technology

ENGINEERING EXPERIMENT STATION

ATLANTA, GEORGIA 30332

July 13, 1982

Mr. Warren Shiver
Newcomb & Boyd
Consulting Engineers
Suite 200, Alpha Building
One Northside 75
Altanta, Georgia 30318

SUBJECT: Deliverable Number 9, June letter Progress Report (A-3095)

REFERENCE: Contract between GTRI and Newcomb & Boyd EMCS Operator Training Manual and Course of Instruction

Dear Mr. Shiver:

This is the eighth of a series of reports addressing the status of the referenced contract. This report covers the period June 1 to June 30, 1982.

STATUS

Met with Newcomb & Boyd project personnel to discuss draft training course deliverable due in late July. With sponsor approval, it was agreed that the deliverable would consist of lesson guides and appropriate portions of the training manual covering Sessions 13- 18, concerning the energy conservation routines. Georgia Tech is to deliver the draft lesson guides by July 23, 1982 to Newcomb & Boyd for inclusion in the deliverable.

PLAN

Complete deliverables as described above.

PROBLEM AREAS

None

FUNDING STATUS

Total contract amount	$77,537.00
Less dollars expended to date	42,605.61
Balance as of June 30, 1982	$34,931.39

Mr. Warren Shiver
July 13, 1982
Page # 2

This concludes Monthly Status Report for A-3095.

Sincerely,

Billy B. Wise,
Project Director
Command and Control Programs
Electronics & Computer Systems Laboratory

Approved:

H. Bennett Teates
Head, Command and Control Programs
Electronics & Computer Systems Laboratory

BBW/HBT:dar

A-3095

Georgia Institute of Technology
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA 30332

August 10, 1982

Mr. Warren Shiver
Newcomb & Boyd
Consulting Engineers
Suite 200, Alpha Building
One Northside 75
Atlanta, Georgia 30318

SUBJECT: Deliverable Number 10, July letter Progress Report (A-3095)

REFERENCE: Contract between GTRI and Newcomb & Boyd EMCS Operator Training Manual and Course of Instruction

Dear Mr. Shiver:

This is the ninth of a series of reports addressing the status of the referenced contract. This report covers the period July 1 to July 31, 1982.

STATUS

Attended several working sessions with Newcomb & Boyd personnel in the course of finalizing format for the EMCS training course lesson guides. Lesson guides for Sessions 13-17 were delivered as planned.

PLAN

Work will continue on other lesson guides and collection of material for the training manual.

PROBLEM AREAS

None

Mr. Warren Shiver
Progress Report
August 13, 1982

FUNDING STATUS

Total contract amount	$77,537.00
Less dollars expended to date	48,332.50
Balance as of July 31, 1982	$29,204.50

Sincerelv.

Billy B. Wise,
Project Director
Command and Control Programs
Electronics & Computer Systems
Laboratory

Approved:

H. Bennett Teates
Head, Command and Control Programs
Electronics & Computer Systems Laboratory

BBW/HBT:dar

A-3095

Georgia Institute of Technology
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA 30332

September 10, 1982

Mr. Warren Shiver
Newcomb & Boyd
Consulting Engineers
Suite 200, Alpha Building
One Northside 75
Atlanta, Georgia 30318

SUBJECT: Deliverable Number 11, August letter Progress Report (A-3095)

REFERENCE: Contract between GTRI and Newcomb & Boyd, EMCS Operator Training Manual and Course of Instruction

Dear Mr. Shiver:

This is the tenth of a series of reports addressing the status of the referenced contract. This report covers the period August 1 to August 31, 1982.

STATUS

Continued work on lesson guides for additional sessions. Established date for delivery of remaining lesson guides and training manual input as September 13, 1982.

PLAN

Work will continue on training course and manual input.

PROBLEM AREAS

None

FUNDING STATUS

Total Contract Amount	$77,537.00
Less dollars expended to date	56,461.25
Balance as of August 31, 1982	$21,075.75

Sincerely,

Billy B. Wise,
Project Director
Command and Control Programs
Electronics & Computer Systems
Laboratory

Approved:

H. Bennett Teates
Head, Command and Control Programs
Electronics & Computer Systems Laboratory

BBW/HBT:dar

A-3095

Georgia Institute of Technology
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA 30332

October 11, 1982

Mr. Warren Shiver
Newcomb & Boyd
Consulting Engineers
Suite 200, Alpha Building
One Northside 75
Atlanta, Georgia 30318

SUBJECT: Deliverable Number 12, September letter Progress Report (A-3095)

REFERENCE: Contract between GTRI and Newcomb & Boyd, EMCS Operator Training Manual and Course of Instruction

Dear Mr. Shiver:

This is the eleventh of a series of reports addressing the status of the referenced contract. This report covers the period September 1 to September 30, 1982.

STATUS

Input to Lesson Guides and Training Manual submitted on time as specified in last month's report. Work continued as scheduled in preparation for pilot course delivery.

PLAN

Input questions for sample test being prepared. Final planning to be completed for course delivery the week of October 25th.

PROBLEM AREAS

None

FUNDING STATUS

Total Contract Amount	$77,537.00
less dollars expended to date	62,625.18
Balance as of September 30, 1972	$14,911.82

Sincerely.

Billy B. Wise,
Project Director
Command and Control Programs
Electronics & Computer Systems
Laboratory

Approved:

H. Bennett Teates
Head, Command and Control Programs
Electronics & Computer Systems Laboratory

BBW/HBT:beg

A-3095

Georgia Institute of Technology
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA 30332

November 24, 1982

Mr. Warren Shiver
Newcomb & Boyd
Consulting Engineers
Suite 200, Alpha Building
One Northside 75
Atlanta, Georgia 30318

SUBJECT: Deliverable Number 13, October letter Progress Report (A-3095)

REFERENCE: Contract between GTRI and Newcomb & Boyd, EMCS Operator Training Manual and Course of Instruction

Dear Mr. Shiver:

This is the twelfth of a series of reports addressing the status of the referenced contract. This report covers the period October 1 to October 31, 1982.

STATUS

Presented sample operator training course at Port Huenume. Received and discussed comments from government review panel. Returned relatively unscathed from the experience.

PLAN

Government comments and improvements as a result of the teaching experience will be incorporated into the lesson guides and training manual.

PROBLEM AREAS

None

FUNDING STATUS

Total Contract Amount	$77,537.00
less dollars expended to date	68,715.00
Balance as of October 31, 1982	$ 8,822.00

Sincerely,

Billy B. Wise,
Project Director
Command and Control System
Electronics & Computer Systems
Laboratory

Approved:

H. Bennett Teates
Head, Command and Control Programs
Electronics & Computer Systems Laboratory

BBW/HBT:khc

A-3095

Georgia Institute of Technology
ENGINEERING EXPERIMENT STATION
ATLANTA, GEORGIA 30332

December 10, 1982

Mr. Warren Shiver
Newcomb & Boyd
Consulting Engineers
Suite 200, Alpha Building
One Northside 75
Atlanta, Georgia 30318

SUBJECT: Deliverable Number 14, November letter Progress Report (A-3095)

REFERENCE: Contract between GTRI and Newcomb & Boyd, EMCS Operator Training Manual and Course of Instruction

Dear Mr. Shiver:

This the thirteenth in a series of reports addressing the status of the referenced contract. This report covers the period November 1 to November 30, 1982.

STATUS

Provided all corrections to lesson guides and training manual, roughs of new viewgraphs, and sample class notes sheet to Newcomb & Boyd on November 12, 1982, as requested.

PLAN

Will complete corrections to lesson guides and training manual, and close project out as of December 31, 1982.

PROBLEM AREAS

None

FUNDING STATUS

Total Contract Amount	$77,537.00
less dollars expended to date	$71,115.07
Balance as of November 30, 1982	$ 6,381.93

Sincerely,

Billy B. Wise,
Project Director
Command and Control Programs
Electronics & Computer Systems
Laboratory

Approved:

H. Bennett Teates
Head, Command and Control Programs
Electronics & Computer Systems Laboratory

BBW/HBT:dar

EMCS OPERATOR TRAINING COURSE DESCRIPTION

Course Objectives

This course is the first of a series of three recommended training vehicles intended to prepare properly qualified applicants to serve as EMCS operators. In accordance with the sample job description included with this report, the objective of this course is to provide candidate operators with an understanding of HVAC system operation through an EMCS, and to train them to perform, in a generic way, in three functional modes.

1. Normal HVAC system operation, including entering parameters for the various energy conservation routines contained in the EMCS Technical Manual.

2. Recognition and response to alarm conditions occurring in HVAC systems contained in the EMCS Technical Manual.

3. Understanding the concept of fine tuning or "tweaking" the system to maximize energy conservation.

Properly qualified candidate operators are assumed to have not less than a high school level education and familiarity with at least one of the skills associated with HVAC, such as refrigeration, controls, steam, etc. In order to meet the training objectives described above, these candidates will have to be instructed in the systems concept of HVAC operation, to include methods of control for the various types of HVAC systems. While the candidates may understand very well maintenance and/or operation of certain HVAC components, such as pumps, or generators, few will have any knowledge of overall HVAC system operation, particularly with the goal of energy conservation. Once an understanding for HVAC system operation is established, the concept of automated or optimized HVAC system control with an EMCS will be introduced. This will involve teaching what an EMCS is and what it can do, focussing more on what it does and less on how it does it. For instance, candidates will be taught about the types of energy conserving programs available, how they interact with HVAC systems, and what inputs are required from the operator. There will be no attempt, however, to get into the software routines themselves, to explain how they function. Emphasis will be given to use of the EMCS as a tool for HVAC control, to make the EMCS transparent to the operator. Finally there is a need to overcome the mystique associated with computers by providing for hands-on practice in computer terminal manipulation as a part of the training course. Trainees will have laboratory sessions where they will have the opportunity to interact with a training device simulating operation and trouble-shooting on an HVAC system through an EMCS.

EMCS Operator Training Course Schedule

DAY	SESSION	TITLE
MON	1	Course Introduction and Pretest
	2	Introduction to HVAC Concepts
	3	HVAC Systems Description
	4	HVAC Systems Description
	5	HVAC Systems Description
	6	HVAC Systems Descsription
TUE	7	HVAC Systems Description
	8	HVAC Systems Description
	9	Introduction to EMCS
	1Ø	Operator Interaction with EMCS
	11	Operator Interaction with EMCS
	12	Operator Interaction with EMCS
WED	13	EMCS Functions
	14	EMCS Functions
	15	EMCS Functions
	16	EMCS Functions
	17	EMCS Functions
	18	Laboratory I

EMCS Operator Training Course Schedule (Con't)

DAY	SESSION	TITLE
THU	19	System Operation and Alarm Analysis
	20	System Operation and Alarm Analysis
	21	System Operation and Alarm Analysis
	22	Laboratory II
	23	Laboratory II
	24	Trend Logs
FRI	25	Review for Test
	26	Administer Written and Performance Test
	27	Administer Written and Performance Test
	28	Review test

Description and Objectives of Class Sessions

SESSION 1. Course Introduction and Pretest

Content

The objectives of the course will be presented and discussed. A class schedule and an abbreviated course outline will be distributed to each student. A written pretest, identical to that given at the end of the course, will be administered. The pretest results will serve as a gauge point for measuring the amount of information from the course retained by the students, and will give the instructors an indication of the student's level of knowledge with regard to HVAC systems and their associated controls.

Learning Objectives

As a potential EMCS operator/supervisor, be able to list and describe the objectives of the training course.

SESSION 2. Introduction to HVAC Concepts

Content

A general introduction to the need for energy conservation and how waste can be reduced through computerized monitor and control of HVAC systems. A more detailed presentation on the concepts of air conditioning, including such topics as what air conditioning is; why is it needed; how heating, cooling and ventilation are accomplished; and the needs for humidification and dehumidification.

Learning Objectives

As a potential EMCS operator/supervisor, be able to:

1. Explain the need for energy conservation.

2. Describe what air conditioning is.

3. Explain why air conditioning is needed.

4. Describe what system ventilation is and how it is controlled.

5. Explain the needs for heating, cooling, humidifying and dehumidifying air.

SESSIONS 3-8. HVAC Systems Description

Content

For each of the HVAC systems contained in the EMCS Technical Manual (TMS-815-2/AFM 88-36/NAVFAC DM-49), with the aid of a schematic-like diagram of the system, describe the configuration of the system, explain what the system is designed to do, discuss how that system is controlled, to include where appropriate information on pneumatic and electric controls, actuators, sensors, controllers and safety overrides. Discuss some ways to conserve energy in the operation of the system.

Learning Objectives

Given a schematic-like diagram of an HVAC system, be able to:

1. Identify the type of system.

2. Explain what the system is designed to do.

3. Describe control methods for the system.

4. Describe at least one way to conserve energy during system operation.

SESSION 9. Introduction to EMCS

Content

Based upon the EMCS Technical Manual and Guide Specifications, discuss what on EMCS is, what is its intended purpose, how the EMCS connects to and controls an HVAC system via "points", and systems other than HVAC which may be controlled by an EMCS. Emphasis will be on use of the EMCS as a tool to control other systems.

Learning Objectives

As a potential EMCS operator/supervisor, be able to:

1. Describe what an EMCS is.

2. Explain the purpose of an EMCS.

3. Describe how the EMCS connects to the HVAC system.

4. Explain how the EMCS provides for monitor and control of the HVAC system.

SESSIONS 1Ø-12. Operator Interaction with EMCS

Content

Based upon the EMCS Technical Manual and Guide specifications, discuss the architecture of a large/medium EMCS system, describing each component and its function. Using the EMCS Operator Training Device, demonstrate operation of control station components, such as the interactive CRT terminal, floppy disk drive, and printer. Demonstrate operator control actions on the CRT terminal using the keyboard, numerical keypad, and touch-activated screen.

Learning Objectives

1. Given an EMCS architecture diagram from the Technical manual, be able to:

    a. Describe the architecture of an EMCS.

    b. Identify the components of the EMCS and explain what each component does.

2. Using the EMCS operator Training Device, be able to:

    a. Operate an interactive CRT computer terminal using keyboard, numeric key pad, and touch screen.

    b. Operate a floppy disk drive.

    c. Operate a printer.

SESSIONS 13-17. EMCS Functions

Content

For each of the energy conservation routines contained in the EMCS Technical Manual and the Guide Specifications, define and describe the routine, to include its application, operation, interaction with the HVAC system, how energy is saved, and required operator inputs. The EMCS Operator Training Device will be used as a teaching aid to demonstrate operator interaction with the routine and subsequent energy savings.

Learning Objectives

Given a list of energy conservation routines from the EMCS Technical Manual, for each routine be able to:

1. Describe what the routine is designed to do.

2. Explain how the routine conserves energy and what is the relative energy savings through its use.

3. List and describe the inputs required from the EMCS operator for operation of the routine.

SESSION 18. Laboratory I

Content

Using the EMCS Operator Training Device, and with guidance from the instructor, students call up energy conservation routines, enter necessary parameters, and observe resultant energy savings.

Learning Objectives

Using the EMCS Operator Training Device, be able to:

1. Call up any energy conservation routine.

2. Explain and enter the inputs required for operation of that routine.

SESSION 19-21. System Operation and Alarm Analysis

Content

Using the EMCS Operator Training Device, demonstrate and describe, for HVAC systems contained in the EMCS Technical Manual, types of alarms which might be encountered by an EMCS operator, identification of critical alarms, diagnosing the cause of the alarm, and corrective actions to be taken. For purposes of testing, specific pre-planned examples will be used in these sessions.

Learning Objectives

Observing the CRT screen of the EMCS Operator Training Device, or paper reproductions thereof, be able to:

1. Describe the alarm condition presented.

2. Determine if the alarm is critical.

3. Diagnose the cause of the alarm condition.

4. Describe prescribed corrective actions.

SESSIONS 22-23. Laboratory II

Content

Using the EMCS Operator Training Device, and with guidance from the instructor, students will practice identification of alarm conditions, diagnosis of conditions which caused the alarm, and taking corrective actions by manipulating the Training Device.

Learning Objectives

Using the EMCS Operator Training Device, be able to:

1. Describe the alarm condition presented.

2. Diagnose the cause of the alarm condition.

3. Enter the proper corrective commands on the operator terminal.

SESSION 24. Log Trends and Reports

Content

Present examples of trend logs and reports, and describe how these records can be used for HVAC system trouble-shooting, increasing of energy savings, and maintenance management.

Learning Objectives

As a potential EMCS operator/supervisor, be able to:

1. Explain how a trend log can be used to trouble-shoot an HVAC system problem.

2. Explain how trend logs and/or reports can be used to increase energy conservation.

3. Explain how reports can be used for maintenance management.

SESSION 25. Review for Test

Content

Instructor will review all material covered during the week course which might appear on the written test.

SESSION 26-27. Administer Written and Performance Test

Content

The writtten test is identical to the pretest administered during the first hour of the course. Comparison of each student's grade on the second test with that from the previous test should give some indication of information learned and retained from the course. The performance test will be conducted using the EMCS Operator Training Device. Students will be given sample tasks, such as set point adjustment, or scheduled start/stop time changes, and must correctly perform the task on the device. Additionally, students will be given sample alarm conditions and be expected to correctly identify the alarm condition, diagnose the cause for the alarm condition, and take corrective action using the trainer.

Learning Objective

Students must reach the level of standard prescribed for the course. If the standard is not initially obtained, the student will review the course material and retake the test until the standard is met.

SESSION 28. Review Test

Content

Instructor will review the written test with the class to reinforce the material presented and clear up any areas of confusion with the students.

QUALIFICATION, BACKGROUND AND TRAINING FOR EMCS OPERATORS

As part of the data collection effort for input to the EMCS Operator Training Course, visits were conducted to four operating EMCS sites. In support of the Tri-Service concept, the visits were planned to include a system being operated by each of the major uniformed services. Sites visited included: Ft. Eustis (Army), U.S. Naval Academy (Navy), Camp LeJeune (Marine Corps), and Charleston AFB (Air Force). To ease the task of comparing and contrasting the existing situations, each site visit involved seeking answers to the following standard set of questions:

- What brand is the system?
- When was the system design?
- When was the system installed?
- When did the system become operational?
- How many points are in the system?
- Does the system conform to the Tri-Service guide specification?
- What was the system design concept, i.e., monitor, control, maintenance, etc.?
- What type of operator interface does the system have?

- o Where there any major problems with the design?
- o What is the system operating schedule?
- o How many trained operators work the system?
- o What is the background of the operators?
- o How were the operators trained initially?
- o Was this initial training adequate?
- o How are replacement operators being trained?
- o Does an EMCS operator position description exist?
- o What are the operator's actual duties?
- o Where do you think the EMCS Operator Training Course would fit in an overall training program?
- o Do you have any suggestions for content of such a course?

Answers were obtained through passive observation and lengthy conversations with design engineers, supervisors and EMCS operators. In every instance, the people at the sites were friendly, helpful and informative. Detailed site visit reports are included in Appendix ____ to this report. This section contains a more analytical discussion of the results of the EMCS site visits.

Summary of Site Visits

The Ft. Eustis Johnson system was designed in 1974, installed over the period 75-77, and became fully operational in its present form in 1978. The system was designed from the top down, with support of every echelon of management, from Base Commander to Supervior of Utilities. Its design concept included functions of system monitor, system control and maintenance management. The EMCS control room is manned 24 hours a day by a rotating team of 5 watch standers. The control room functions as an energy control center for the entire Base. There is direct communication with the maintenance divisions during normal working hours and at all other times the duty EMCS operator handles incoming utilities trouble calls and dispatches duty mechanics. Through automatic monitoring of equipment run time, the EMCS generates scheduled tasks in preventive maintenance for all maintenance divisions.

The operators were recruited out of the maintenance divisions on the post. Job applications were carefully screened and each applicant was given an intensive personal interview to evaluate not only the individual's background experience, but also the motivation to function as an HVAC system operator. Great emphasis was placed on hiring operators who truly understood, or were willing to learn, how to actually operate an HVAC system. The EMCS operator positions were classified as WG-11, and movement of the individuals from the shop to operator status was a notable promotion. The operators were trained through a combination process of schooling on the system by Johnson, rotation through all of the utilities maintenance shops over a one-year period of system installation, and on-the-job experience in the control room.

In terms of system design and implementation, operator recruitment, training, and retention; and overall system operation, Ft. Eustis comes closer to a model situation than any other EMCS site visited by the investigators.

The EMCS at Annapolis was not acquired through a typical system design, but came as an add-on to a single new building project. The building was designed with a very sophisticated HVAC system which would have required constant roving operators. The alternative was to install a computerized building monitor system, and thus was born the Annapolis EMCS. Additional buildings have been connected to the Johnson system on a piece-meal basis over the years, by little add-ons to MILCON projects. The system is used primarily to monitor and control air handlers. The 7000-ton chiller plant is not controlled by the EMCS and the central heating plant is not connected to the EMCS at all. The Annapolis EMCS is manned 24-hours a day by five operators on a rotating shift basis. The EMCS operators are classified as chiller plant operators at the WG-5 level, and actually spend a good portion of their duty shift making rounds through mechanical rooms and directly operating chillers. The operator works under the direction of the main heating plant watch supervisor, who is located in the heating plant itself, far removed from the EMCS control room. None of the supervisors have any training on or familiarity with the EMCS.

EMCS operators were recruited primarily as chiller plant operators, thus they tend to have a background in refrigeration. A few of the operators attended the Johnson school on the EMCS, but most were trained strictly on the job. There is no question that energy is being conserved through EMCS use at Annapolis, but this site is for removed from matching the efforts at Ft. Eustis, for instance.

The existing EMCS at Camp LeJeune was installed by CSC in 1978-79. It is connected to about 70 buildings on the post, all of which are occupied 24 hours a day. Each building has its own 25-30 ton air conditioner for cooling, and is heated by steam from 8 centralized boiler locations. The primary emphasis with this system is on demand limiting during the cooling season. The system monitors building temperature and turns the air conditioners on and off to control it. There is a load shedding program which automatically turns loads off in response to increasing projected demand. In the heating season, building temperature is controlled by opening and closing a single solenoid operated steam valve in each building.

The LeJeune system is presently manned 8 hours a day, five days a week, by a single operator. Outside of these hours, watch standers at the maintenance trouble desk will respond only to alarm buzzers triggered by high water levels at the sewage lift stations. The operator has a computer background and was trained by rotating through maintenance shops and going on service calls with experienced personnel for one year, and by on-the-job work with the EMCS for an additional year. The job is classified at the GS-5 level.

The EMCS at Charleston AFB is a Honeywell Delta 2000 which was installed in 1971 as a maintenance troubleshooting aid, long before rising energy costs focused attention on conservation. In 1974, the system was expanded for energy conservation applications, and a 10-channel Honeywell load shedding system was installed with it. The system is used primarily for demand limiting in the cooling season, using start/stop through the EMCS, and load shedding with the dedicated Honeywell system. The EMCS is manned during normal work hours, five days a week. The system is connected to 65 buildings on the Base. The central steam plant is not included in the system and chillers are only monitored, not controlled.

The current operator at Charleston has a background in air conditioning and heating, and the position is classified as WG-10. Training was conducted entirely in-house on the EMCS itself.

Observations

At nearly all of the sites visited, both in the course of this investigation and in previous studies, the most proficient EMCS operators are those who have a background in HVAC. That is not to say that candidates with other backgrounds cannot be trained to be good operators; however, the essence of the EMCS operator's job is operation of an HVAC system. Perhaps the title "EMCS Operator" is a misnomer, and the position should be more correctly described as "HVAC Operator." While it is true that the operator uses a sophisticated EMCS with its digital computer as a control medium, the EMCS from the operator's standpont is merely a tool, much the same as an oscilloscope or ratchet wrench. Thus, it is far more important for the operator to understand the operation of the HVAC system, than that of the EMCS. The operator needs to know how to control the HVAC system with the EMCS, but beyond that the EMCS should be transparent to the operator.

Response to the need to train candidate EMCS operators was remarkably similar at the installations visited. In almost every case, candidate operators were assigned to the various utilities maintenance divisions for periods of up to a year. During these assignments, candidate operators would accompany experienced HVAC maintenance people into the field on trouble calls, and theoretically thereby learn about HVAC system operation. An even more effective field training situation is one in which candidate operators can observe actual installation of the EMCS "points" on the HVAC system by contractor personnel. There are several problems associated with this training technique. First of all, EMCS installers are not in most cases fully acquainted with HVAC operation themselves and are thus not well qualified to teach others. Secondly, HVAC maintenance personnel, while being well-versed in their individual fields of endeavor, do not necessarily understand HVAC on the system level. Thirdly, candidates who do not have an HVAC background are overwhelmed by the exposure to detail of HVAC components as observed during field maintenance. Finally, while this type of field training is applicable to training of the initial group of operators, supervisors will seldom have the luxury of being able to put a replacement operator candidate in the field for a year.

Operator training provided by the EMCS vendor normally focuses on the EMCS itself, and not on operation of the HVAC system. This phase of training is undoubtedly necessary for candidate EMCS operators, but it is not by itself sufficient.

Recommended Training Program

The recommended program for training candidate EMCS operators consists of three phases.

- o EMCS Operator Training Course
- o Vendor Training
- o On-the-Job Training

The EMCS operator training course should be the first scheduled training phase for EMCS operator candidates. The objective of this initial course is to provide candidate operators with an understanding of HVAC system operation through use of an EMCS, and to train them to perform, in a generic way, in three functional modes.

1. Normal HVAC system operation, including entering parameters for the various energy conserving routines contained in the EMCS Technical Manual.

2. Recognition and response to alarm conditions occurring in HVAC systems contained in the EMCS Technical Manual.

3. Understanding the concept of fine tuning or "Tweaking" the system to maximize energy conservation.

This type of training course will fill a knowledge gap recognized at every EMCS site visited, that is a lack of candidate operator understanding of HVAC operation at the system level. This course will be based on the HVAC systems and EMCS designs and energy-conserving routines contained in the Tri-Service EMCS Guide Specifications and EMCS Technical Manual. While every base EMCS installation is unique, and no one installation will have all the HVAC systems and EMCS capabilities contained in the Tri-Service publications, it is deemed appropriate for several reasons to include all of the aforementioned information in the initial course. Due to funding limitations, most base EMCS installations are installed in phases over several year's time. Each phase usually involves a new design effort to most effectively integrate the existing EMCS with the proposed expansion. Experienced operators, with knowledge of EMCS capabilities beyond those existing in the current system they operate, can provide valuable input to the new design effort. In many situations it is noted that operators intimately associated with the peculiarities of a given HVAC installation are able to provide recommendations for new EMCS capabilities for better than any outside design engineer. Knowledge of the spectrum of energy-conserving routines available can allow operators, as they gain experience in working with their unique installation, to envision hybrid modifications to their programs to improve energy conservation. This would be for less likely to occur if candidate operators are exposed to only that subset of capabilities contained in their specific base system. This course is designed to provide a generic introduction to and training in the operation of HVAC systems under EMCS control for candidate EMCS operators and supervisors, thus it is appropriate that the course cover all of the capabilities contained in the Tri-Service publications. Operators will get site-specific information in the second and third phases of their training, as described below.

The second phase of candidate EMCS operator training should be the EMCS vendor's schooling on the equipment being installed at the site. This training will include how to operate the vendor's brand of EMCS equipment, and how to interface with vendor's energy conservation routines. In the past, this phase of training has met with measured success, because the candidate operators entering the vendor training had almost no knowledge of HVAC system operation nor of EMCS functions. To complicate matters further, this vendor training is normally intended to train candidate operators on how to manipulate the vendor's system, and does not by design teach the broader topics of HVAC system operation and general EMCS capabilities. Because the candidate operators will have already completed the generic introductory training course, they will be able to focus their attention on learning the specific installed system, and learning efficiency will be improved.

The final phase of EMCS operator training will be on-the-job training (OJT). In this phase, candidate operators might alternate between working shifts in the EMCS control room and working shifts in the utilities maintenance divisions for a period of several months. This type of training will complete the relationship between the classroom oriented training in phases one and two, and the actual HVAC and EMCS hardware at the specific site. This last phase of training will be totally site-specific. This OJT phase could occur during EMCS installation, or after the EMCS has been placed into full operation, without loss of effectiveness.

EMCS operator training programs reviewed to date have been extremely lengthy (1 to 2 years), and have not incorporated adequate training in HVAC operation at the system level. The training program recommended in this report overcomes both of these shortcomings. This training program starts with a very generic approach to HVAC system operation and EMCS capabilities (the EMCS Operator Training Course), proceeds through more specific training on the installed EMCS (Vendor Training), and ends with site-specific hands-on training and experience with HVAC and EMCS systems (OJT). This whole training cycle could be completed in about six months, including the one-week EMCS Operator Training Course, 2-3 weeks for Vendor Training, and up to 5 months in OJT.

NEED AND REQUIREMENTS FOR TRAINING DEVICE

Introduction

This section contains discussion on the needs and requirements for a training device to be used in conjunction with the EMCS Operator Training Course. The objective of the course is to provide candidate operators with an understanding of HVAC system operation through an EMCS, and to train them to perform, in a generic way, in three functional modes.

1. Normal HVAC system operation, to include entering parameters for the various energy conservation routines contained in the EMCS Technical Manual.

2. Recognition and response to alarm conditions occurring in HVAC systems contained in the EMCS Technical Manual.

3. Understanding the concept of fine tuning or "tweaking" the system to maximize energy conservation.

In order to meet the course objective, candidate operators will be instructed and trained in the systems concept of HVAC operation, to include methods of control for the various types of HVAC systems; the concept to automated or optimized HVAC system control with an EMCS, to include what the capabilities of EMCS are; and the manipulation of interactive computer terminal equipment. This type of instruction and training cannot be effectively accomplished without the use of a hands-on training and demonstration device.

Functional Requirements

The demonstration and training device will be used in two different modes. At times the device will be used by the instructor to demonstrate techniques, capabilities, and results as a part of the lecture series. At other times the device will be used by the students in hands-on laboratory sessions for practice and for performance testing at the end of the course. In Sessions 10-12, the device will be used to demonstrate and practice operator manipulation of an interactive computer terminal; various operator interface techniques such as command line mnemonics, menu penetration, and interactive graphics; and operation of peripheral devices such as floppy disk drives and a printer. In Sessions 13-17, the instructor will use the training device to demonstrate interaction with the energy conservation routines contained in the EMCS Technical Manual. The device must accommodate parameter entry, and simulate interaction of the EMCS routine with the HVAC system as well as representing energy savings. In Session 18, the trainees will operate the device to practice the actions and observe the reactions described by the instructor in the previous four sessions. In Sessions 19-21, extensive use will be made of the device by the instructor to demonstrate HVAC system operation, and the diagnosing of and response to alarm conditions. In Sessions 22-23, the trainees will use the device for hands-on practice of the operations demonstrated by the instructor in the three previous sessions. The device will be used on Session 24 to demonstrate the printing of logs and reports. Finally, the training device will be used in Sessions 26 & 27 to administer performance tests as described in the course outline.

Technical Requirements

The concept for delivery of the EMCS Operator Training course is to take the course to each site where an EMCS is to be installed, and present the course to candidate EMCS operators and supervisors. Class size might number as many as ten students. In order to facilitate taking the course to EMCS sites, the trainer will have to be transportable. Likewise, the device should be able to fulfill all of its functions in a stand-alone mode, i.e., it should not be dependent on a host computer for its operation. To enable easy viewing of the device CRT screen in the demonstration mode, provision should be made for a standard video interface. In this way, video monitors can be hooked to the device to provide multiple close-up views of the screen. The training device must be able to simulate in a satisfactory manner operation of HVAC systems, energy conservation routines, and resultant energy savings, log and report printing, and alarm diagnosis and correction. The trainer must be capable of demonstrating different types of operator interfaces, such as CLM, menu penetration and interactive color graphics.

Hardware Description

The Chromatics color graphics stand-alone computer system should be capable of accommodating the requirements described above. This equipment was used in developing and implementing a man-machine interface demonstration device for interactive color graphics as a control technique, and with appropriate software it should also function well as a trainer and demonstration device for the course. To meet the requirements for the course, the Chromatics computer would have to be equipped with an interactive touch screen, CP/M operating system, and a standard video interface, in addition to its hardware based color graphics generation capability. Peripheral devices would include floppy disk drives and a line printer. Since the major work with the hardware configuration has already been accomplished, development efforts for the trainer would involve mostly software generation.

A 3095

December 21, 1982

MEMORANDUM

To: Distribution
From: B. B. Wise BBW
Subj: A-3095 Deliverable Number 16

The attached sheets constitute deliverable number 16 on project A-3095. Included herein are:

(1) EMCS Operator Training Manual, Sections 2.1 and 2.2

(2) EMCS Operator Training Course Lesson Guides for the following lessons:

Lesson 3 Session 9
Session 10
Session 11
Session 12
Lesson 4 Session 13
Session 14
Session 15
Session 16
Session 17
Session 18
Lesson 5 Session 23
Session 24

(3) EMCS Operator Training Course student class notes sheets for Lessons in (2) above.

These sheets are to be collated with others produced by Newcomb & Boyd to assemble the deliverable documents. Accordingly, because these sheets do not in themselves constitute complete documents and because they are intended to be collated with other materials, they have appropriately not been bound nor provided with covers and title sheets.

CHAPTER 2

ENERGY MONITORING AND CONTROL SYSTEMS

SECTION 1. INTRODUCTION TO EMCS

An Energy Monitoring and Control System (EMCS) is an energy management system which allows for centralized monitoring and control of dispersed energy consuming equipment.

Over the past thirty years, energy monitoring and control systems have undergone an evolutionary process. The evolution has basically been from strictly monitoring systems to control plus monitoring systems.

Prior to modern EMCS systems, building temperatures, pressure, etc., were monitored from a central location, generally the building engineer's office. Panel banks in the office were connected to sensors and controllers throughout the building. These systems were generally used only in large individual buildings. Other than to start and stop equipment, the central panel banks offered little control over the equipment they monitored.

The systems developed in the 60's provided scheduled start-stop and manual temperature control point adjustments. Temperatures and pressures were monitored, but instead of gauges and dials, digital displays were incorporated. One important feature of these systems was the provision for reporting alarm conditions. These were the first systems to utilize computers where monitored data was stored in memory (electronically recorded and retained for later use). The Central Processing Units (CPU) had numerous individual signal wire connections which came directly from each monitored component. Due to technological limitations, making changes to the systems was severely limited. The manufacturer had to make any changes. Possible changes were limited to circuitry provided during manufacturing.

Performance of the hardwired logic units improved significantly as a result of combining them with a means to transmit data between various system components. In these transmission systems, individual sensors and controllers were wired to a field panel installed near the sensor locations. From the field panel, the signals were sent on to the CPU. Technology had been developed such that a number of signals could be transmitted along the same conductor. Therefore, this system required the installation of only a two or four wire cable from the CPU to panels in mechanical rooms throughout a building instead of the many multi-conductor cables necessary for previously described systems. Once this system configuration was developed, multi-building complexes began to utilize the concept of central monitoring and control. The technical capability to combine or multiplex signals over a few wires has reduced tremendously the cost of data transmission media, thereby making the EMCS concept cost effective for DoD installations. This type system was common on college campuses and was used in early military base EMCS installations.

A major improvement in system flexibility and performance was the replacement of the hardwired logic CPU with a small general-purpose computer. This allowed the manufacturers to easily modify and program the system. It also provided for greater flexibility in utilizing the monitored information. Data was collected, calculations performed, and appropriate control commands or alarms sent to the field controllers. The ability to modify or program the systems was, however, not passed on to the customer. Consequently, from the customer's standpoint, it was a major project to have the manfacturer add a point to the system, change constants related to a point, or add specialized instructions for computer operation. In general, only the original manufacturer was capable of performing these actions, thus resulting in a non-competitive procurement situation.

The above evolution generally describes the process with which major conventional controls manufacturers developed the systems they are marketing today. A different group of manufacturers has appeared on the scene within the past five years. These manufacturers are generally smaller firms with backgrounds in process control applications or general computer systems applications.

Their approach has been to use off-the-shelf computer, data transmission, and sensor components. The components are combined with computer software to form an EMCS. These manufacturers claim to provide greater flexibility and adaptability to the customer for less cost. Their main support for this argument is that their systems generally allow the customer the capability to write programs, modify existing programs, and retrieve monitored data, which is not possible with most of the major conventional control systems. This has resulted in competition which is now causing a re-evaluation of the system design philosophy of the major control manufacturers.

The energy crisis and the advent of computer based systems also brought new interest and direction to central control applications. The rapid rise of energy costs, coupled with increased system capability to reduce energy consumption, has improved the economic feasibility of energy monitoring and control system application. Although the systems have not reduced manpower as expected, some manpower savings are possible and will be realized. More importantly, the energy conserving control aspects of the systems are of such value that they can be justified on that basis alone.

As described above, central control systems have evolved from systems whose principal value was the monitoring of points, to systems whose principal value is the control of equipment. Because of this process of evolution, with its inherent inertia, problems have occurred. The engineering design process has not kept pace with the change in purpose of the EMCS from monitoring to control. Many recently installed systems include a number of points whose only purpose is monitoring of equipment, which effect no direct energy savings.

Various military installations have been involved in all stages of the evolutionary process described above. Many large individual buildings, such as hospitals, contain the hardwired central panel systems. The first base-wide systems which instrumented multiple buildings were procured when the data transmission system in conjunction with the hard logic CPU became available. At that time the principal justification for procurement of such systems was the monitoring of equipment to reduce manpower requirements. Minimal control was available or emphasized in these early projects. The installations attained varied operational success, but virtually all of the systems failed in the manpower reduction objective.

Generally, insufficient funds are available at one time to purchase full capability for every building on a base. The result of this limitation is that a reduced system is procured by not connecting some or many of the buildings on a given base. This approach results in the selection of many monitoring functions with no associated energy savings in one building, while another building is not connected to the EMCS at all. An alternative to this approach is to delete monitoring points from the first building and connect energy conserving points, or energy control points in the second building. Whether or not to delete monitoring points is a decision of management that has to be looked at on an individual basis based on past experience.

Generally, the design philosophy for military EMCS programs has enlarged to include the energy conscious approach. Systems now under design are being configured on the basis of energy savings as well as O&M functions. A number of complex problems involved in determining the optimum configuration of an EMCS for a particular base have been defined as a result of this enlargement in design philosophy. The complexity of the problems stems from the inter-relationship of costs to perform alternative EMCS activities.

Purpose of an EMCS

The prime purpose behind the development and use of EMCS is conservation of energy. Energy conservation is accomplished primarily through close monitoring and control of HVAC systems. Traditionally, HVAC systems on military posts were installed building by building during construction or renovation. Even on posts with centralized steam and/or chiller plants, the buildings were widely dispersed making it impossible to maintain a close watch over energy consumption. It was nearly impossible to control energy consumption so as to conserve it. Heating and cooling equipment was energized at the start of the appropriate season, usually as a function of the calendar and with little regard for unseasonable weather conditions. The equipment was allowed to run continuously until the mandated end of the season. The usual result was that building occupants were either too hot or too cold and opened windows to regulate the temperature, thereby increasing energy consumption. Further, HVAC systems ran 24 hours a day because there was no feasible way to turn the widely distributed equipment on and off. There was also no provision for resetting space temperatures during unoccupied periods. The EMCS allows for both the centralized monitoring and control of energy consumption on a widely dispersed HVAC system. While the prime use for an EMCS is for monitoring and controlling HVAC equipment, it may also be used for lighting control, sewage lift station control, maintenance management, and fire and security alarms.

EMCS Attachment to the HVAC System

EMCS systems have been developed to provide centralized monitoring and control of dispersed energy consuming equipment. An EMCS connects to an HVAC system through monitor and control points. Monitoring and control functions are accomplished through use of a computer.

Where the EMCS and an HVAC system connect is called a point. There are two kinds of points:

1. Control points which allow the EMCS to send information to the HVAC system in the form of commands, and

2. Monitor points which sense temperatures, pressures, flow rates, etc., on the HVAC system and send information to the EMCS. There are typically five to ten times as many monitor points in an EMCS as there are control points.

There are two primary types of measurement and control used in HVAC applications: two position and modulating (proportional). Two position control devices designate one of two operational modes, such as on/off or open/closed. Two position measurement sensors detect if the equipment is on or off, open or closed. Two position type measurement also can be used to sense whether a measured variable is above or below a set value. For example, a freezestat can detect whether or not a temperature is above 40°F.

Modulating or proportional control devices set an actuator or motor at any position between on or off (open or closed). For example, a modulating control device may be used to position a valve to regulate the flow of water. As the valve position varies from open to closed, the flow rate of water varies from full flow to no flow. Proportional measurement produces a signal whose value is related to the value of a physical parameter. For example, a temperature sensor produces a output signal which is proportional to the temperature it is measuring. Such devices generally have a limited range over which they operate. For example, a temperature sensor designed to measure room temperature would be reasonably accurate over the range of 50° to 100°F, but would not be accurage for measuring boiler stack gas temperatures on the order of 1000°F.

The types of sensors or output devices used at the monitor and control points vary depending on their function. The following list presents examples of monitor point devices and what they monitor.

DEVICE	MONITORS
Air flow switch	Air flow status
Water flow switch	Water flow status
Freezestat	Provide warning when heating or cooling coils are in danger of freezing
Flame sensor	Flame failure
Auxiliary contacts	On/off status (motors, fans, etc.)
Analog sensors	Temperature Pressure Humidity Voltage Current

The following are examples of EMCS control points, the devices used and their function.

DEVICE	FUNCTION
Relays	Motor ON/OFF
Controllers	Temperature Pressure

Typical monitor and control points for a single zone AHU are shown in Figure 2-1. Monitoring and control point designations are defined in Figure 2-2.

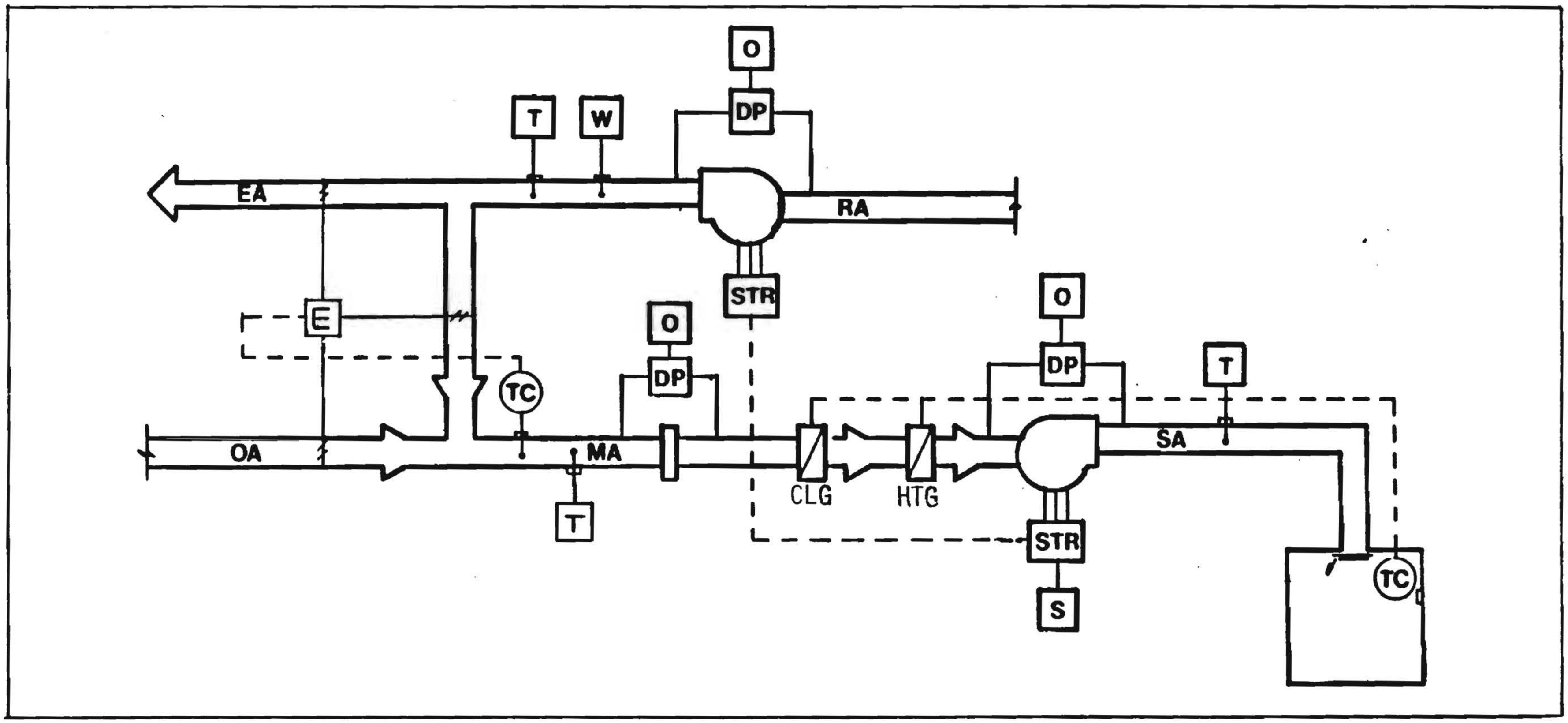

Figure 2-1
Typical Monitor and Control Points on Single Zone AHU

→ EMCS	SIGNAL TRANSMITTED TO EMCS
← EMCS	SIGNAL RECEIVED FROM EMCS
A	ALARM CONTACT SIGNAL
C	GREATEST COOLING DEMAND
E	ENTHALPY/ ECONOMIZER CONTROL INTERFACE
F	FLOW INDICATION
FL	FLAME INDICATION
H	GREATEST HEATING DEMAND
P	PRESSURE INDICATION
LV	LEVEL INDICATION
M	METER
O	ON - OFF STATUS SIGNAL
DP	DIFFERENTIAL PRESSURE SWITCH
R	CONTROLLER RESET INTERFACE
S	START - STOP INTERFACE
T	TEMPERATURE INDICATION
V	VENTILATION/RECIRCULATION CONTROL
W	HUMIDITY INDICATION
PS	POSITION

TC	TEMPERATURE CONTROLLER
DS	HIGH - LOW DEMAND SIGNAL SELECTOR
STR	MOTOR STARTER
	SENSOR INSTALLED IN THERMOMETER WELL
	SENSOR INSTALLED IN DUCT OR PLENUM
CHW	CHILLED WATER
EA	EXHAUST AIR
PC	PRESSURE CONTROLLER
SA	SUPPLY AIR
RA	RETURN AIR
OA	OUTSIDE AIR
MA	MIXED AIR
WB	WET BULB
DB	DRY BULB
OAD	OUTSIDE AIR DAMPER
RAD	RETURN AIR DAMPER
EAD	EXHAUST AIR DAMPER
MZD	MULTIZONE DAMPER
RH	RELATIVE HUMIDITY

Figure 2-2
Point Designations

To accomplish the tasks of monitoring and control, the EMCS uses a computer, HVAC system instrumentation and controllers, and some type of communications link between the EMCS computer and the HVAC system. Figure 2-3 shows the system concept.

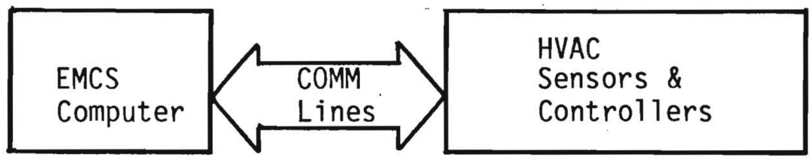

Figure 2-3
EMCS/HVAC COMMUNICATION LINK

With an EMCS, it is possible for one operator, working from an operator's console at the EMCS computer site, to monitor the operation of all connected HVAC systems on the military post. Likewise, the operator may send out HVAC system control commands to any piece of attached HVAC equipment.

EMCS Architecture

An EMCS is classified according to the total number of monitoring and control points connected to the system as follows:

1. Over 2000 points .... large EMCS

2. 500-2500 points .... medium

3. 50-600 points .... small

4. Less than 125 points .... micro

Basically the functions of the combined system operations are to monitor all data points, excecute energy conservation programs, and produce control signals to operate equipment in the real-time environment.

Large EMCS Architecture

A modern large EMCS consists basically of several small computers, peripherals, and monitor/control equipment. A computer is defined as any device which can receive and store a set of instructions, and then act upon them in a predetermined and predictable fashion. Also, the data and instructions can be changed. Computer software are the programs which instruct the computer. Figure 2-4 shows the layout of a large size EMCS.

Computers

Large EMCS use several computer systems including the Central Control Unit (CCU), Central Processing Unit (CPU), and Central Communication Controller (CCC).

The Central Control Unit is a small computer that functions as the overall system coordinator. It implements the energy conservation programs, performs, complex calculations, and controls peripheral devices. The Central Processing Unit is the portion of the computer that interprets and executes instructions. The software controls operations of the CPU and its peripheral devices.

While operating under energy conservation programs, environmental conditions and power consumption rates are predicted. Proper equipment operating point settings are calculated and control signals are produced to operate the equipment in actual-time. Data and programs are stored in memory or mass storage devices such as magnetic tape or disk systems. For high speed transfer of data between the CCU and mass storage device, the CCU has direct memory access (DMA) controllers. The DMA transfers data in blocks. The CCU has designated connections, called Input/Output (I/O) ports, for specific equipment, such as printers and terminals. It provides the interface between the operator and the EMCS. During normal operation, the CCU coordinates operation of all the EMCS components, except safety interlocks.

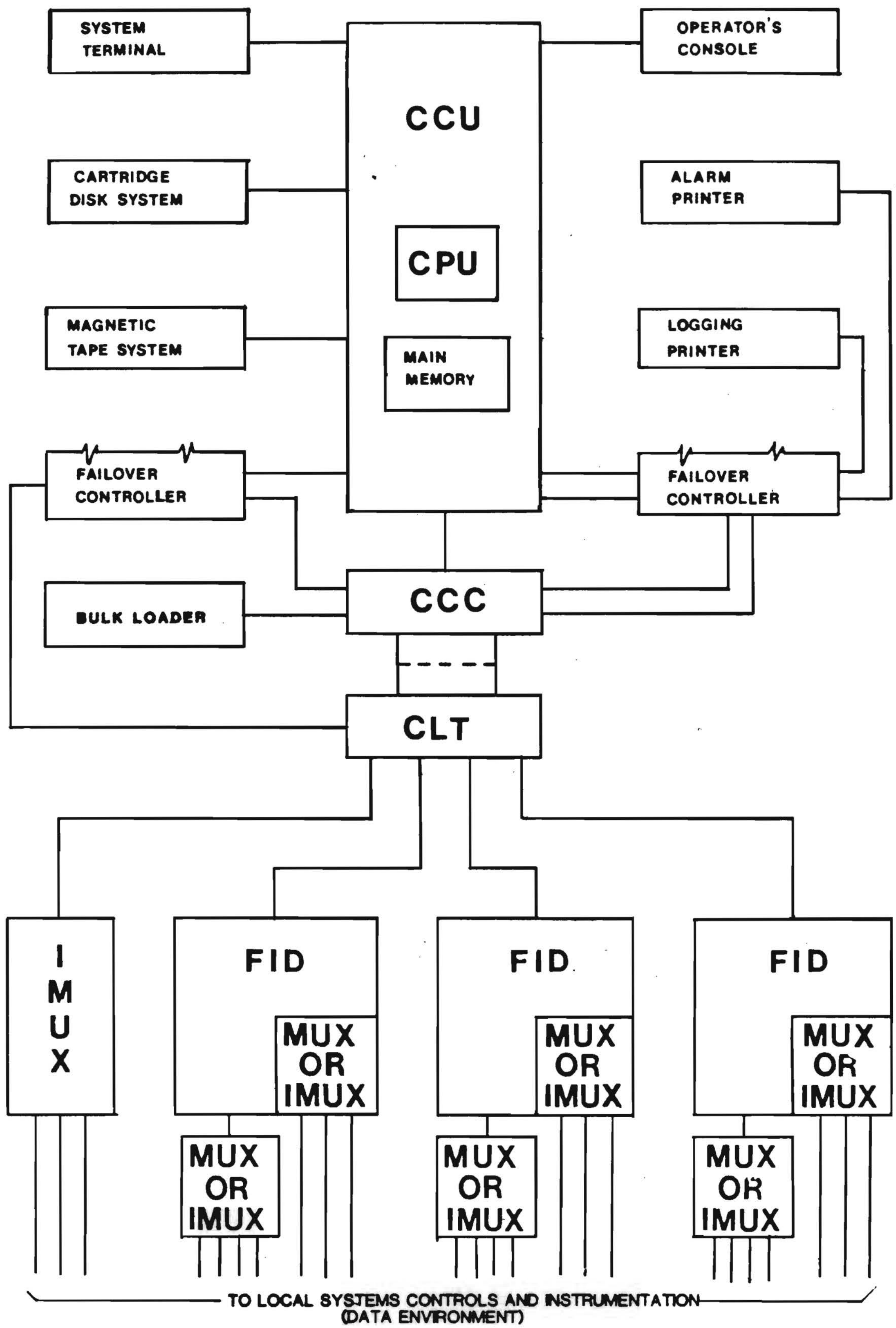

Figure 2-4
Large EMCS Architecture

The Central Communication Controller is a small computer that collects and disseminates data to and from control and monitoring points. In addition to transferring data, it can change the format of data presentation, check for errors, and retransmit data between the CCU and other equipment. In the event of CCU failure, it provides limited backup. The CCC relieves the CCU of time consuming communications with other equipment; allowing the CCU to devote its full capabilities to the execution of control, monitoring, and applications software programs. In the event of CCU failure, the CCC provides for limited backup.

Peripherals

Peripheral equipment controlled by the CCU includes the following:

The system terminal is a television screen or cathode ray terminal (CRT) which displays letters and numbers and is used to perform system commands, develop and modify system programs, and run software diagnostic tests.

The operator's console is an eight color CRT terminal that displays shapes and colors in additional to numbers and letters. It is the primary operator-system interface. It graphically displays equipment schematics, system status, operating parameters such as temperatures and pressures, and operational-data.

The console contains a dedicated keyboard for entry of operator commands. Trends of selected equipment variables can be plotted, enabling the operator to make strategy decisions regarding equipment operation. Graphic displays may be brought up automatically when an alarm is activated, or upon operator command.

Data Storage Devices store data for later use. Disk and tape systems are utilized. The disks or tapes store information on their magnetic surfaces like a tape recorder. Disks are either hard or flexible (diskettes) and spin like a record. A device called a drive, spins the disk or winds the tape. It contains a device called a head, which can read information from the magnetic surface as well as write information. The computer can move the head to any location on the surface of a disk. This is called random access. The storage systems used in an EMCS include:

The cartridge disk is a high density mass storage system with random access and removable disk capability. It is used to store the EMCS system, command, and applications programs.

The Winchester disk can also store the EMCS operational programs and instructions. It is a high density mass storage system with random access. The disks are extremely susceptible to dust, dirt, and cigarette smoke. Therefore, the system is sealed and the disks cannot be removed. Because of manufacturing technology, Winchester disks are more reliable than cartridge disks.

A flexible or floppy disk is a medium density storage system with random access and removable disk capability. They are utilized for giving start-up instructions to the computer and historical data storage. The diskettes are circular vinyl disks, enclosed in rigid plastic envelopes. The envelope protects the diskette during handling and use. Openings in the envelope allow the head access to grip the diskette surface. The diskette spins freely inside the envelope and is driven by the head. The diskette should never be removed from its envelope.

A magnetic tape system is a nine-track high density mass storage system, with removable tape capability. Data is stored and accessed sequentially, making data retrieval slower than from a random access disk system. They are used when large amounts of data is stored but will be accessed only periodically.

Two key-board printers are provided with a large EMCS. They are used to obtain permanent copies of data or system operations. The alarm printer is dedicated to reporting alarms. The logging printer logs data and prints reports. Each must be capable of serving as a backup for the other.

The EMCS system clock must be synchronized with an actual-time clock at regular intervals. This is done with the System real-time clock (RTC) which is provided with a battery backup.

A failover controller is provided for automatic and manual switching of the CCU, CCC and printers to the backup mode of operation should the CCU, CCC or printers fail.

A bulk loader is a mass storage device used to load EMCS software into the system.

The central control unit, central communication controller, operator's console, system terminal, data storage devices, printers, and other peripherials are located in the master control room (MCR).

The Communications link termination (CLT) is the communications interface between field equipment and Master Control Room (MCR) equipment. It concentrates data, as required, for interface to the CCC/CCU.

Field Equipment

The following components make up the field equipment, which is located in the vicinity of the data environment, (sensors and control devices connected to a single FID/MUX/IMUX from the equipment and systems sampled or controlled).

Field Input Device (FID)
Multiplexer (MUX) Panels, and
Intelligent Multiplexer (IMUX) Panels.

The Field Interface Device (FID) is a small computer which collects data from sensors within its Data Environment (DE) and generates commands to control operating devices such as electric motors, valves, and relays. The FID controls parameters such as temperature, and humidity without input from the CCU. Commands from the CCU and the operator console will cause the FID to adjust operating parameters such as: temperature and humidity set points, and start/stop times. The FID transmits equipment operating data and status, as well as alarm messages, to the CCU.

The FID has sufficient computer capability to operate without communications with the central computing system. Failure of the FID does not adversely affect performance of the rest of the system except for those optimization programs performed at the central computing system, which require data from the FID. The FID can perform optimization routines normally performed by the CPU when there is a cost or operational advantage. FIDs can be added, as required, to incorporate additional buildings or systems.

Multiplexer (MUX) Panel. MUX panels serve as I/O devices for a FID and its DE, and are considered to be extensions of the FID. The number of remote MUX panels connected to a single FID is limited by (a) the maximum number of panels addressable by a FID, (b) the number of points allowed on a single DTM, or (c) by the alarm response time. The remote MUX panels continuously transmit data to the FID via a MODEM or line drivers. The MUX panel contains I/O fuctions to handle digital and analog data, digital data error detection, and message transmission. Failure of a MUX must return the attached HVAC equipment to local loop control or to a pre-determined failure mode. MUX panels usually have a battery backup to sustain operation during a power failure.

Intelligent Multiplexer (IMUX) panels are similar to MUX panels, but operate in a "report by exception" mode, i.e. the IMUX scans its DE and compares the data received against the last value and reports only the data that has changed. IMUX panels perform all functions of a MUX panel and, depending on manufacturer, are used in place of the MUX panel. The IMUX is allowed to communicate with the CCU/CCC in large and medium systems in a monitoring role only, thereby retaining the distributed intelligence inherent in the FID - CCU/CCC architecture. The IMUX is allowed to perform both monitoring and control functions in the small and micro systems. The IMUX also performs data communications checking and retransmission to the CCU/CCC. Failure of the IMUX returns the attached HVAC equipment to local loop control or to a predetermined failure mode. I/O IMUX panels usually have a battery backup to sustain operation during a power failure.

Medium, Small, and Micro EMCS Architecture

A medium EMCS, approximately 500 to 2500 points, consists of the following major components:

1. Minicomputer based CCU (16 bit minimum).
2. Color graphics CRT based operator's console.
3. Alphanumeric CRT based system terminal.
4. Alarm printer with keyboard.
5. Logging printer with keyboard.
6. Cartridge disk systems.
7. Bulk software loading device.
8. System RTC.
9. FID, MUX, and IMUX panels.

10. Magnetic tape system (optional).

11. CLT.

The three components of a large EMCS, not incorporated into the medium system are the central communication controller, failover controller, and bulk loader. The typical medium EMCS architecture is shown in Figure 2-5.

A small EMCS, approximately 50 to 600 points, consists of the following major components.

1. Minicomputer or microcomputer based CCU.

2. Alphanumeric CRT based operator's console.

3. Alarm and logging printer.

4. Bulk software loading device.

5. System RTC.

6. FID, MUX, and IMUX panels.

7. CLT.

A typical configuration is shown in Figure 2-6.

A micro EMCS, less than 125 points, consists of the following major components.

1. Microcomputer based CCU.

2. System RTC.

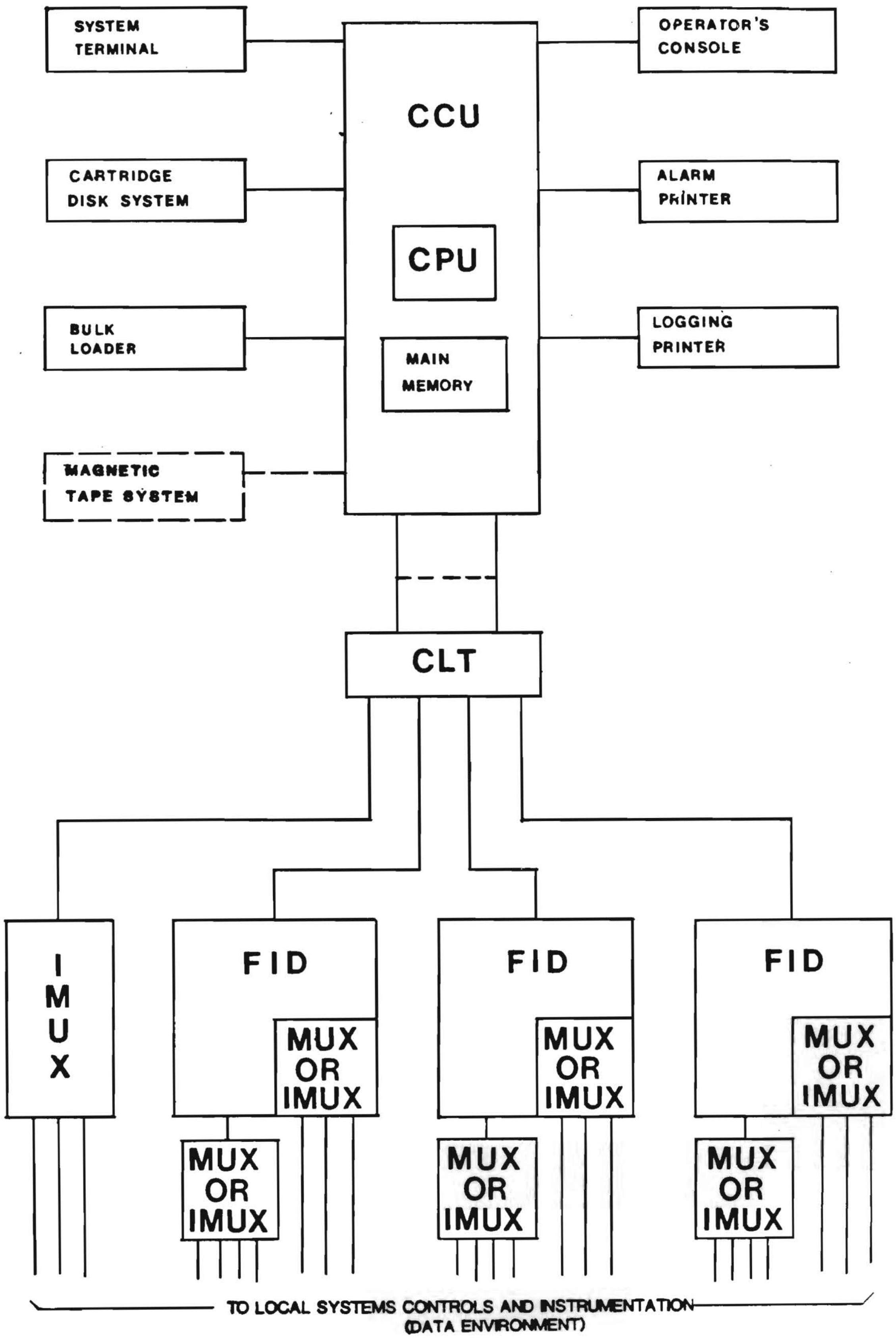

Figure 2-5
Medium EMCS Architecture

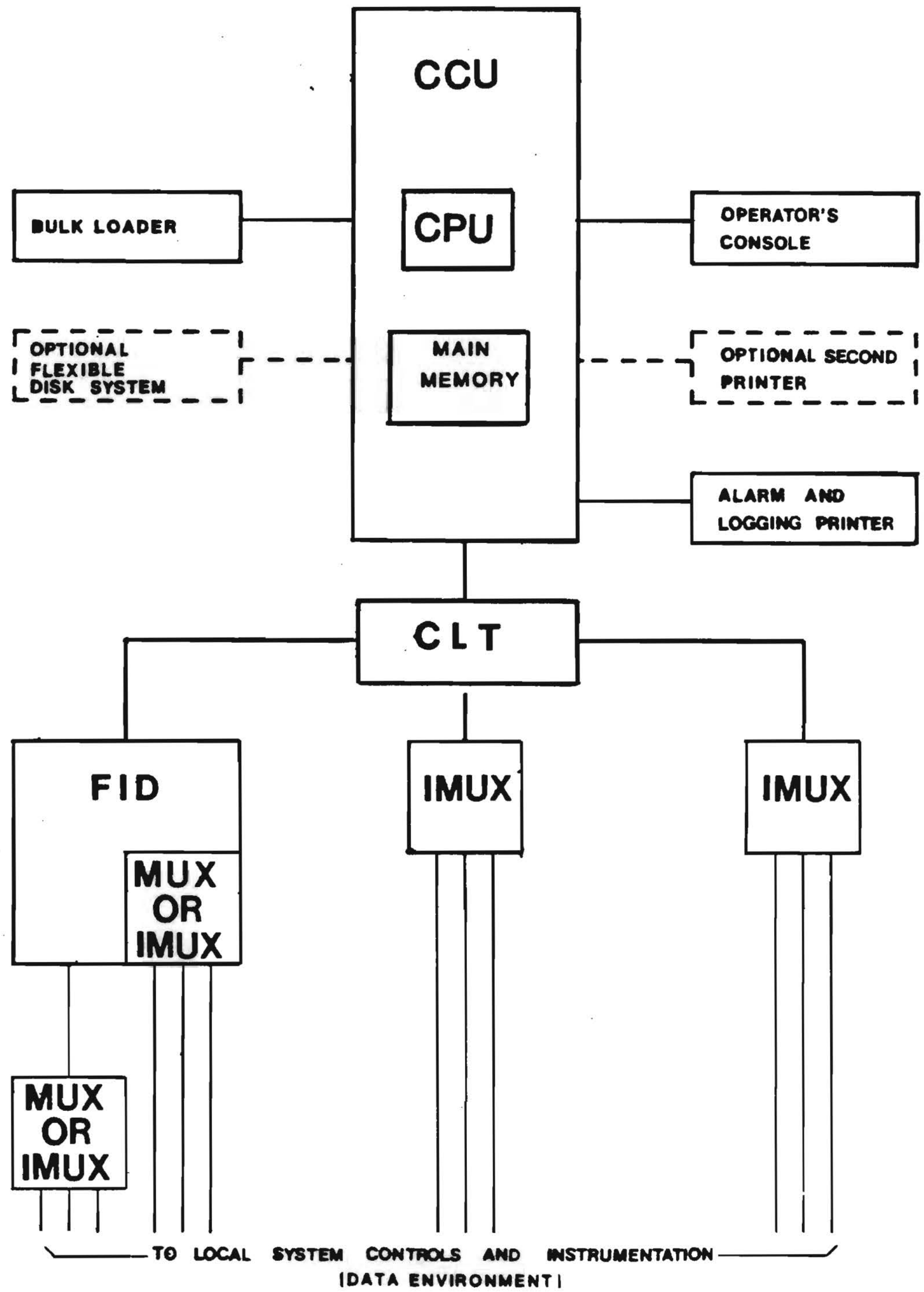

Figure 2-6
Small EMCS Architecture

3. IMUX panels.

4. Programming and service panel (removable).

5. CLT.

A typical configuration is shown in Figure 2-7.

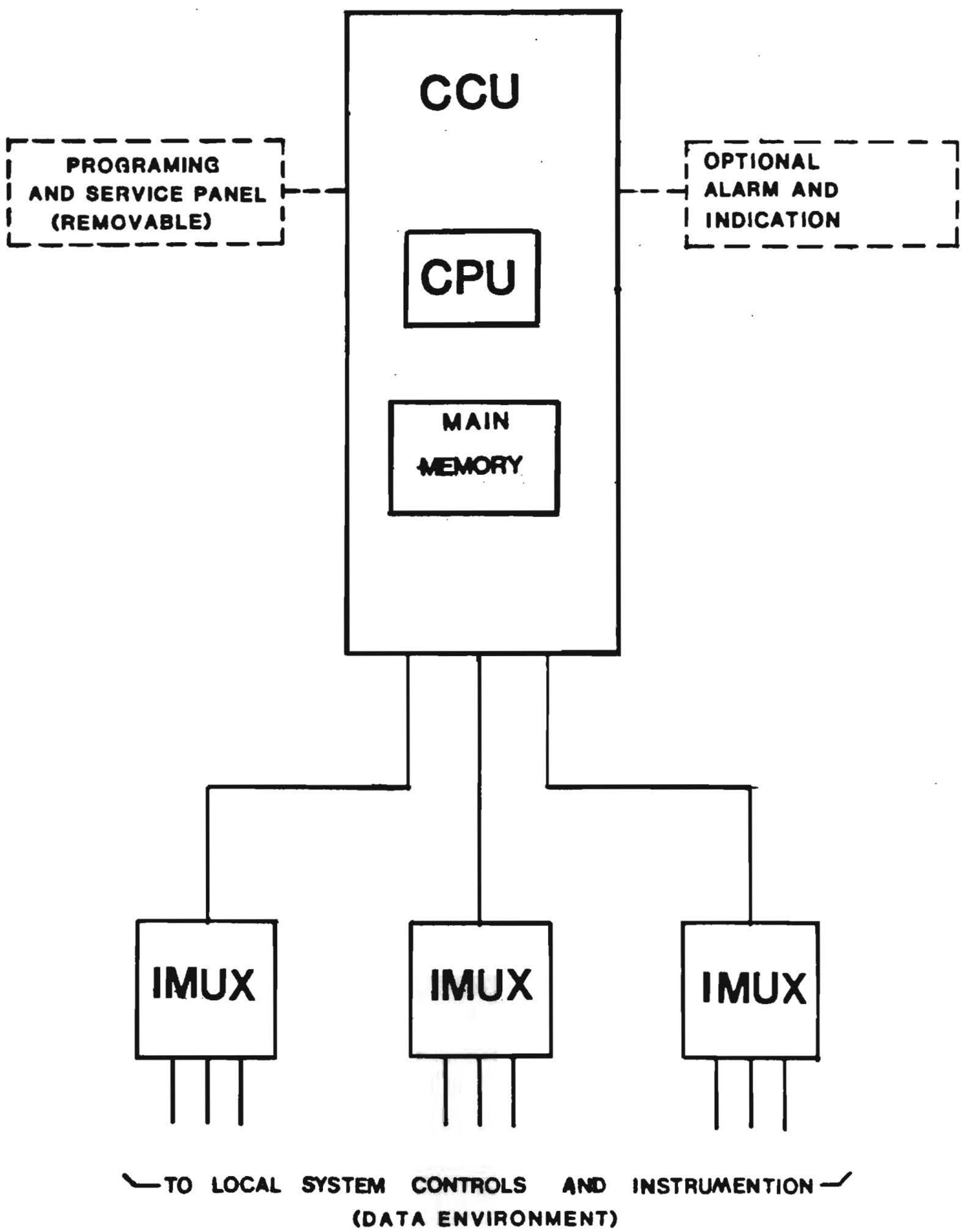

Figure 2-7
Micro EMCS Architecture

SECTION 2. OPERATOR INTERACTION WITH THE EMCS

The operator's terminal is the communication link between the operator and the EMCS equipment. Even though an EMCS is computer controlled, there is still a need for human intervention. The console accepts operator commands and displays data and graphical representations of systems controlled or monitored by the EMCS. Using the console the operator may initiate software programs, control various equipment, and adjust setpoints. The EMCS monitors and controls energy consuming equipment such as motors, fans, water chillers, etc. Should equipment malfunction, an alarm is relayed to the operator.

There are four basic types of operator interfaces which may be encountered on EMCS's. The four different types include command language, command line mnemonic, menu penetration and interactive color graphics.

Command Language

The command language interface technique uses a black and white CRT terminal. The basis of the command language interface is a command library, consisting of abbreviated (2 to 5 characters) symbolic "words", or commands. A basic command word will usually have associated with it a number of modifiers or arguments, which follow the command word and are separated by some type of punctuation symbol, such as a comma, semicolon, or slash mark. Figure 2-8 shows some examples of typical commands.

```
KIL, LOOP NAME/ALL
TIM,HOUR, MINUTES
LOC, L1,<L2>, <L3>
LOG, <L1>,<L2>,<L3>,<OUTPUT DEVICE>
RM, L1, L2, L3, <DEL>
CHL, L1, L2, L3, <DEL>
AHU, L1, L2, L3, <DEL>
FSI, <DEVICE>
```

Figure 2-8
Sample Command Library

The operator controls the HVAC system by typing on the CRT keyboard the appropriate command for the desired function. Command libraries can contain hundreds of different commands, and these must be learned by the operator, or looked up in some reference book, for the operator to be able to use the EMCS. The EMCS responds to the operator by displaying similar symbolic words on the CRT screen. The command language technique features a very precise, rapid interaction with the EMCS computer. However, this precision of interaction has the undesirable side effect of making the technique inflexible and unforgiving. If the operator mistypes a command, omits a required modifier, or misplaces even a comma, the EMCS will not recognize the command and will respond only with an error message like "syntax error". The command language interface technique was the first one to be used with EMCS's and will be found in a large majority of operating systems.

Command Line Mnemonic

The command line mnemonic (pronounced nee-mon'-ic) interface technique represents a step taken towards improving the "friendliness" of the operator interface with the EMCS computer, i.e., making the system easier to use. The command line mnemonic (CLM) interface also uses a black and white CRT terminal, but unlike the command language interface, the CLM prompts the operator for necessary inputs with plain English phrases or words. The operator initiates the input sequence with an English-like command word. The EMCS computer thereafter prompts the operator for command modifiers or arguments until all input requirements are met. The operator then presses the "ENTER" key, which terminates the current input routine and sends the input commands on to the EMCS computer. In the computer, a software program called a CLM interpreter (CLMI) reads and translates the input command sequence. The CLM interface is much slower to operate than is the command language interface. This is because with the CLM, the computer generates multiple cues and responses for each input command sequence, and the CLMI must translate each command sequence. Thus, the trade-off for ease of operation with CLM is reduced operating speed. Conversely, the very precise input commands in the command language interface allow for rapid input entry, but require the operator to memorize unnatural symbolic command words and any associated modifiers or arguments.

Menu Penetration

The menu penetration interface technique is an attempt at regaining the speed of operation associated with the command language interface, while retaining the ease of operation of the CLM interface. Menu penetration uses a black and white or color CRT terminal which displays menus or lists of commands and input values from which the operator simply selects the desired item. Figure 2-9 shows a sample menu of buildings or data environments.

1. BLDG 21
2. BLDG 23
3. BLDG 67
4. BLDG 68
5. BLDG 329
6. BLDG 602

Figure 2-9
Sample Menu-First Level

To select an item from a menu, the operator need type in only the number of the desired item. With the command language and CLM interfaces, the entire command word or symbol, including modifiers and arguments must be entered. Thus, the menu penetration interface allows more rapid operator input from a given menu. Selection of an item from the first level building menu shown in Figure 2-9, results in the system displaying a second level menu of equipment types, shown in Figure 2-10.

1. General
2. Air Handling Equipment
3. Heating Equipment
4. Refrigeration Equipment

Figure 2-10
Equipment Menu-Second Level

Operator selection of an item from the equipment menu causes the EMCS computer to display a third level air handling equipment menu, Figure 2-11.

1. AHU # 1
2. AHU # 2
3. AHU # 3
4. AHU # 4
5. RELIEF FANS

Figure 2-11
Air Handling Equipment Menu-Third Level

This process of penetrating from menu level to menu level continues until all of the required inputs to accomplish a desired function have been completed. The process of penetrating through the levels of menus takes additional time compared to the very precise command language inputs, however, the simple single key stroke entry saves time and requires almost no typing skill on the part of the operator.

Interactive-Color Graphics

The interactive color graphics (ICG) interface technique is the latest development in operator interface technology, and promises to provide the fastest and easiest to operate interface produced to date. The ICG interface uses a color CRT terminal equipped with a touch interactive feature on the CRT screen. Figure 2-12 shows the presentation provided on the ICG interface CRT. The basis for operator interaction with the terminal is a schematic-like diagram of the data environment HVAC system, and a set of touch-activated "push-buttons". By simply touching the appropriate "push buttons" and EMCS point interactive touch targets on the CRT screen, the operator can accomplish all of the typical control functions listed in Figure 2-13. The only typing required is the inputting of numerical values when called for by cues to the operator appearing along the lower edge of the ICG screen. None of the three previously described interface techniques (command language, CLM, menu penetration) has incorporated any type of diagram of the HVAC system being controlled. In early systems, the only way for an operator to identify devices and equipment within the controlled HVAC system was by reference to a computer-printed table. Tabular data does not provide a very graphic description of a system and is certainly not the type of presentation familiar to typical EMCS operators. Most EMCS operators come from the ranks of HVAC mechanics, and thus are accustomed to working with schematic-like diagrams of systems. To overcome the lack of graphic information associated with early EMCS operator interfaces, manufacturers provided 35 mm slides of system diagrams in projector devices located in the EMCS control room. Thus, to identify a given air handler in a building, the operator would have to flip through the slides to find the appropriate building diagram. As EMCS operator interface technology moved to the menu penetration scheme, vendors began to provide color graphic CRT's for the EMCS control room upon which could be displayed full color HVAC system diagrams as called by the operator from a menu. The next logical step in interface development was to combine the necessary

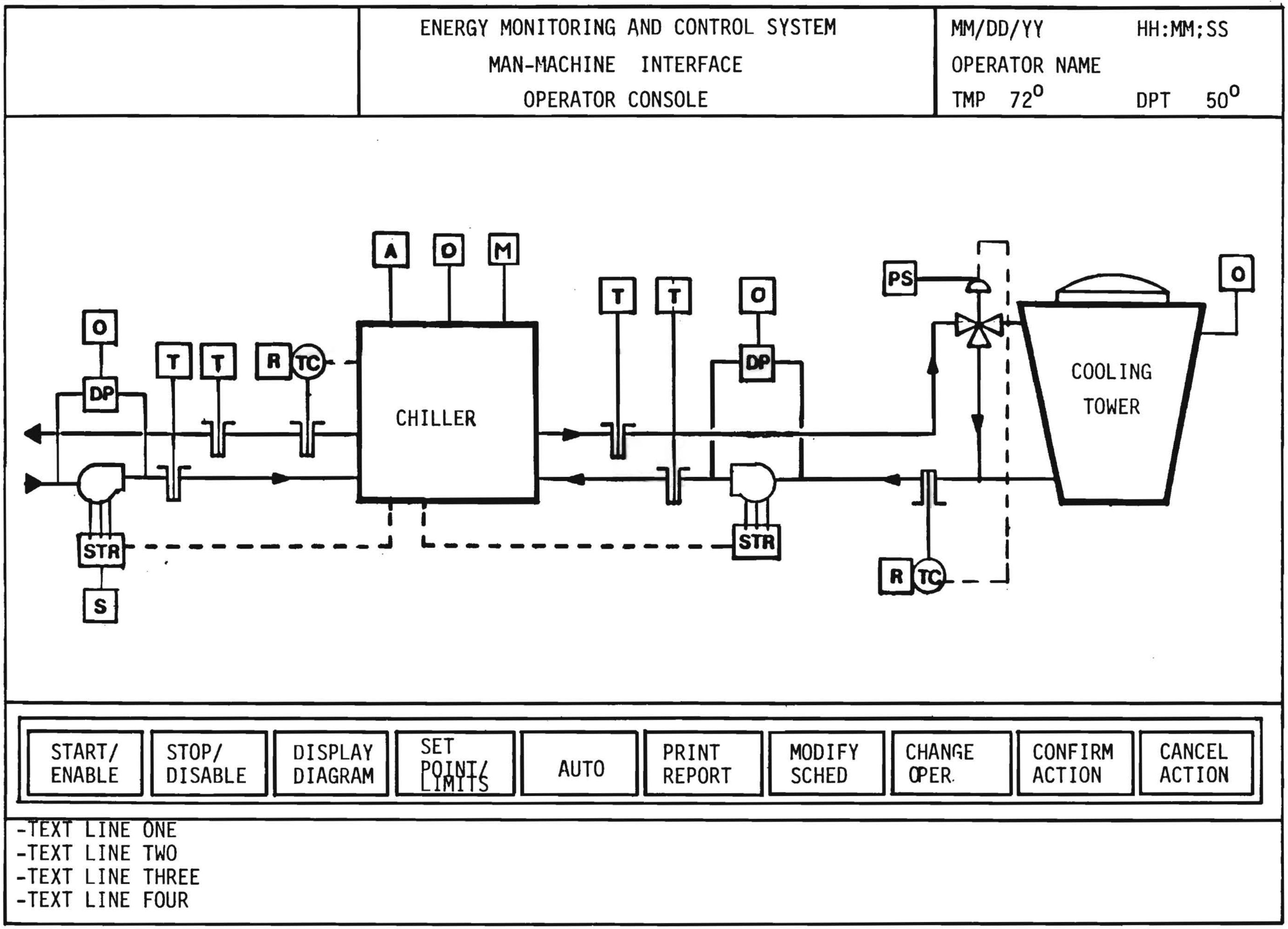

Figure 2-12
Interactive Color Graphics Screen

diagrammatic HVAC system display with the required operator command input capability. Thus, the ICG interface uses elements from all of the previous interface techniques to make the EMCS fast and easy to operate.

- o Request a display of any digital or analog point, or any group of related points in the system.
- o Startup and shutdown of selected systems or devices.
- o Initiate reports.
- o Request graphic displays.
- o Modify time and event scheduling.
- o Modify analog limits.
- o Adjust setpoints of selected controllers.
- o Select manual or automatic control modes.
- o Enable and disable individual points; disabling shall take precedence over all other actions.
- o Enable and disable individual FIDs.
- o Enable and disable individual MUX or IMUX panels.
- o Point definition.

Figure 2-13
Operator Tasks

Operation of the ICG Terminal

The operator's terminal consists of a keyboard and CRT display screen. The display screen is equipped with an interactive touch panel. Approximately one inch in front of the screen is an array of infrared beams which are continuously sent from the top to bottom of the screen area. The beam can be interrupted by an object such as a pencil or finger. This allows the operator to interact directly with information presented on the screen. This minimizes the need for typing.

The screen is divided into five major areas:

1. Date/time/operator (continuously displayed)

2. Graphics display area

3. Special function keys

4. Message/text area, and

5. Alarm indicator.

The screen layout is shown in Figure 2-14.

The alarm area will be blank under normal conditions. Under an alarm condition the area will flash in red. The date, time, and operator's name are entered from the keyboard.

SPECIAL FUNCTION KEYS

Ten Special Function keys allow the operator to instruct the computer to perform complicated commands by simply touching the screen.

The START/ENABLE key is used to manually start mechanical equipment and to enable monitoring and control components such as a FID, MUX, or data point.

The STOP/DISABLE key is used to manually stop mechanical equipment and to disable monitoring and control components.

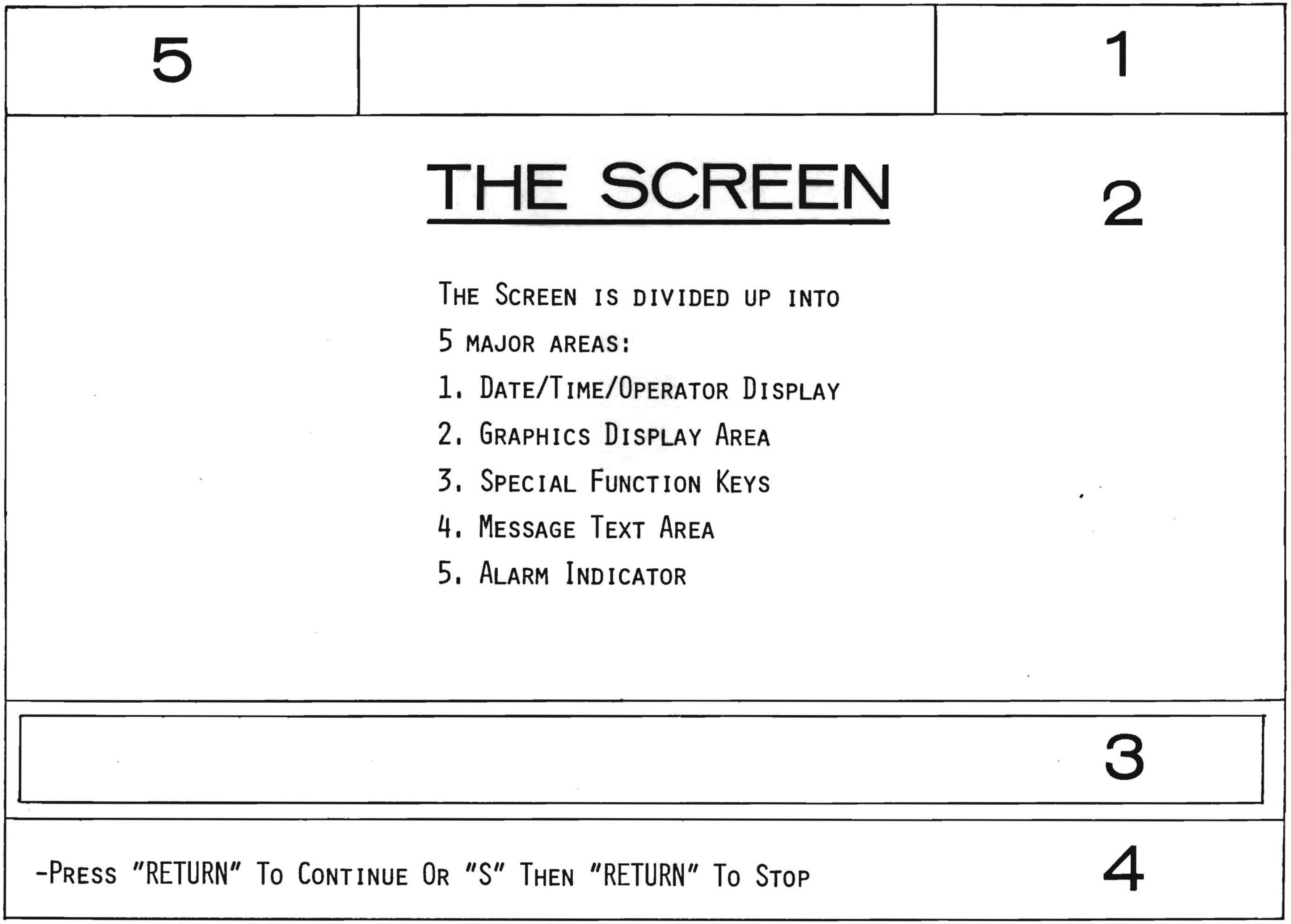

Figure 2-14
Interactive Screen Layout

The DISPLAY DIAGRAM key is used to display HVAC diagrams of specific data environments (DEs) in the graphics display area. When the DISPLAY DIAGRAM key is touched a list of the DEs possible for selection is presented in the graphics display area. When the square beside the desired area is touched, the square will change color to indicate that it has been selected. When the CONFIRM ACTION key is touched it becomes backlighted, the DISPLAY DIAGRAM key backlight extinguishes, and the selected diagram is presented in the graphics area.

The AUTO/MANUAL key is used to select or indicate the operating mode of a particular data environment. This key has three different representations on the screen:

1. When no DE is being displayed, the key will read "AUTO" or "MANUAL" in black letters.
2. When a DE running in an automatic mode is displayed, the key will have "AUTO" printed on it in blue letters.
3. When a DE is operating in a manual mode, the key will read "MANUAL" in green letters. To change the mode of a device touch the device to be changed then to the CONFIRM ACTION key to execute.

The PRINT REPORT key allows the operator to initiate printing of special reports. Touching the key will result in a list of available reports to be displayed on the screen. The message "Touch Square Beside Desired Report" will appear in the text area. Touching the CONFIRM ACTION key will result in the report being printed.

The MODIFY SCHED key is used to modify the automatic schedule of operation for a particular data environment. When a DE is displayed, touching the MODIFY SCHED key results in a list of schedule selections being displayed on the screen. The procedure to modify a schedule is the same as that for changing point settings or limits: touch the square beside the desired selection; type in the changes; after all changes have been made, touch the CONFIRM-ACTION key.

The CHANGE OPER key is a multipurpose function key for changing operator or operation. It allows the operator to shut down the system, request the HELP program, or change operators. When the key is touched these messages are displayed, "Ready to Change Operator/Operation" and "Enter Command or New Operator Name From Keyboard." The system will then accept one of three commands: Operator Name, HELP, or STOP. Type in the desired command followed by the Return Key. When an operator's name is typed in, the system assumes that an operator change is taking place and that future commands should be recorded under a new name. The HELP command is used to enter the on-line HELP program. The STOP command may be used to shut down the EMCS.

The CONFIRM ACTION key is used to assure the system that the desired command sequence has been entered and ready to be executed.

The CANCEL ACTION key performs the opposite function of the CONFIRM ACTION key. It can be used any time prior to touching the CONFIRM ACTION key, to signal the system to abort the current command and return to the previous state.

To adjust setpoints or limits of a point of an HVAC system displayed in a diagram, the SET POINTS/LIMITS key must be touched. The key will become backlighted, and "Touch Appropriate Device Symbol" will appear in the text area. When the device symbol has been touched the message "Touch CONFIRM ACTION" will be presented in the text area. Once the confirm action key is touched, a list of set point, low limit, and high limit with touch sensitive squares will be presented, as shown in Figure 2-14. The low and high limits being the minimum and maximum desired values for a points.

One or all points or limits can be changed one at a time. Limit changes are made by touching the desired selection and typing in the desired value after the message "Please Type In the New Value" appears in the text area.

The confirm action key must be touched after the final limit has been changed.

Floppy Disk Drive Operation

In many EMCS's, the computer software programs are loaded into the machine from a floppy diskette. The diskette comes in two envelopes. The outer one must be removed to load the diskette, the inner envelope is permanently fixed and must never be removed. The first step in loading a diskette is to open the loading slot door on the disk drive unit. This door will usually have some simple type of latching mechanism which is released by a pinching motion with the fingers. Remove the diskette from its outer envelope, and hold it in the right hand with the thumb on top of the diskette label. Gently push the diskette all the way into the loading slot, then close the disk drive door by pushing on the handle. To remove a diskette, simply release the latch on the door and the diskette will pop out of the slot. The disk drive power switch must usually be actuated manually. When handling a diskette, do not touch the plastic diskette surface with the fingers. Diskettes must be stored away from high heat sources and magnetic devices.

Additional Operator Functions

In addition to monitoring and controlling HVAC equipment through use of the operator's console, an EMCS operator has several other functions or duties to perform. From time to time the operator will be required to perform minor equipment maintenance, such as replacing ribbons and paper on the printer, trouble shooting equipment in the main control room (MCR), possibly replacing circuit boards to restore equipment to normal operating condition. An operator will also occasionally have to "boot-up" or restart the EMCS computer programs. Equipment maintenance and program restart procedures are site peculiar, and will be governed by local operating instructions and taught as part of the vendor's training. the EMCS operator is also responsible for safeguarding of the EMCS computer programs. In most EMCS installations, the computer programs are the proprietary material of the system contractor and may not be given out to any unauthorized individuals. Locking cabinets are usually provided in the MCR for storing this proprietary material.

Another important factor is that the EMCS operator is only one part of a team of individuals who must work in a coordinated manner if the EMCS is to fulfill its goal of energy conservation. The EMCS operator in the MCR is the focal point, but interaction with both base management and HVAC maintenance personnel is vital. Base management personnel must be informed as to the capabilities, limitations and objectives of the installed EMCS, so that they will be supportive in establishing necessary operating policies which are not always popular with base tenants. Likewise, HVAC maintenance personnel must understand what the EMCS can do for them, how it can help them in locating the cause of trouble calls and in doing preventive maintenance.

SESSION TITLE: Introduction to EMCS

SESSION TIME: 50 minutes

SESSION TYPE: Lecture

OBJECTIVES: 1. To describe what an EMCS is. 2. Explain the purpose of an EMCS. 3. Describe how the EMCS connects to and provides monitor and control of a HVAC system.

INSTRUCTOR REFERENCES: EMCS Design Manual, Ch.2, Sec.1

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2, Sec.1

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0000	INTRODUCTION	
	Introduce basic concepts of energy monitoring and control systems. Discuss purpose of EMCS and how it connects to, monitors, and controls HVAC systems.	
0001	DEFINE EMCS	V9-1 EMCS DEFINITION
0002	DISCUSS BACKGROUND AND EVOLUTIONARY PROCESS	
	Monitoring to control plus monitoring	
	Discuss centralized instrument panel banks	
	Discuss system design from 60s.	
	Discuss hardwired logic units and improvements	
	Discuss changing to computers and reasons for changes	
	Describe systems on military bases	
0017	EXPLAIN PURPOSE OF EMCS	
	Energy conservation	
0018	DESCRIBE HOW EMCS CONNECTS TO HVAC SYSTEMS	V9-2 POINTS DEFINITION
	Define monitor points	
	Define control points	

EMCS OPERATOR TRAINING COURSE
LESSON 3 - SESSION 9

SESSION TITLE: Introduction to EMCS

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
	Show sample diagrams - Two pipe fan coil - Single zone AHU	V9-3 TWO PIPE FAN COIL V9-4 SINGLE ZONE AHU
0028	DESCRIBE SYMBOLS AND ABBREVIATIONS FROM DESIGN MANUAL	V9-5 SYMBOLS AND ABBREVIATIONS
0033	DISCUSS MONITOR AND CONTROL TECHNIQUES AS APPLIED THROUGH EMCS - Describe EMCA/HVAC Link - Analog points, modulation - Digital points, two-position	V9-6 EMCS/HVAC LINK V9-7 MULTIZONE AHU V9-8 HOT WATER BOILER
0048	REVIEW SESSION	

SESSION TITLE: EMCS Design

SESSION TIME: 50 minutes

SESSION TYPE: Lecture

OBJECTIVES: 1. Describe the architecture of EMCS systems. 2. Identify each component of an EMCS. 3. Explain what each component does.

INSTRUCTOR REFERENCES: EMCS Design Manual, Ch.2, Sec.2

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2, Sec. 2.

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0000	INTRODUCTION Describe EMCS components, what they do, and how they are combined to form a system.	
0001	DEFINE CLASSIFICATIONS OF EMCS SYSTEMS	V10-1 EMCS SIZE CLASSIFICATION
0003	DESCRIBE FUNCTIONS OF MAJOR COMPONENTS OF TYPICAL MICRO EMCS CONFIGURATION Microcomputer-based CCU - Implements energy conservation routines Performs calculations Controls peripheral devices CPU - Interprets and executes instructions Main memory - Stores instructions Real-time clock (RTC) Intelligent multiplexer panel (IMUX) Combines data from DE points and sends it to the CCU, reports by exception Programming and service panel (removable) Human interface to CCU Communications link termination (CLT) Interface between field equipment and Master Control Room equipment	V10-2 MICRO EMCS ARCHITECTURE

SESSION TITLE: EMCS Design

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0013	DESCRIBE FUNCTIONS OF ADDITIONAL MAJOR COMPONENTS OF TYPICAL SMALL EMCS CONFIGURATION Operator's console Primary operator/system interface Alarm printer Prints alarm messages only Logging printer Prints all command actions transacted via the operator's console Bulk software loading device For loading computer programs Field interface device panel (FID) Collects data from sensors and generates commands. May provide for distributed control of DE. Multiplexer panel (MUX) Combines data from DE points and interfaces with the FID Flexible disc system Auxiliary data storage device	V10-3 SMALL EMCS ARCHITECTURE
0028	DESCRIBE FUNCTIONS OF ADDITIONAL MAJOR COMPONENTS OF TYPICAL MEDIUM EMCS CONFIGURATION Minicomputer System terminal CRT used for program development and maintenance Rigid disk system Auxiliary data storage device with greater capacity than flexible disk system	V10-4 MEDIUM EMCS ARCHITECTURE

SESSION TITLE: EMCS Design

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
	Magnetic tape system	
	Auxiliary data storage device with greater capacity than rigid disk system	
	Color graphics capability	
0038	DESCRIBE FUNCTIONS OF ADDITIONAL MAJOR COMPONENTS OF TYPICAL LARGE EMCS CONFIGURATION	V10-5 LARGE EMCS ARCHITECTURE
	Central communications controller (CCC)	
	Reformats, transfers and performs error checks on data between the CCU and FIDs	
	Failover controller	
	Switches CCU, CCC and printers into backup mode of operation in the event of component failure	
0046	REVIEW SESSION	

EMCS OPERATOR TRAINING COURSE
LESSON 3 - SESSION 11

SESSION TITLE: Operator Interaction with EMCS

SESSION TIME: 50 minutes

SESSION TYPE: Lecture & Demonstration

OBJECTIVES: Introduce students to various operator interactions with training device.

INSTRUCTOR REFERENCES: EMCS Operator Training Manual, Ch.2, Sec.2.

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2, Sec. 2.

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0000	INTRODUCTION	
	Demonstration of various methods of operator interaction with an EMCS, including command line mnemonics, menu penetration, command language and interactive graphics.	
	USING THE FOLLOWING TASKS:	
	1. Startup and shutdown of selected systems or devices 2. Adjustment of setpoints 3. Schedule modification 4. Request display of points	
	DEMONSTRATE INTERFACE TECHNIQUES	V11-1 INTERFACE TYPES
0002	COMMAND LANGUAGE INTERFACE	Trainer Routine INTERFACE TYPES
0012	COMMAND LINE MNEMONIC	
0022	MENU PENETRATION	
0032	INTERACTIVE COLOR GRAPHICS	
0042	DEMONSTRATE DISK DRIVE OPERATION	
0045	DISCUSS SOME OTHER OPERATOR FUNCTIONS Minor equipment maintenance System restart Interaction with administrative and maintenance personnel	V11-2 ADDITIONAL OPERATOR FUNCTIONS

EMCS OPERATOR TRAINING COURSE
LESSON 3 - SESSION 12

SESSION TITLE: Laboratory I. PAGE 1 OF 1

SESSION TIME: 50 minutes

SESSION TYPE: Laboratory

OBJECTIVES: 1. For students to become familiar with the various types of operator interfaces using the EMCS Operator Training Device; operation of CRT computer terminal using keyboard, numeric key pad, and touch screen, operation of a floppy disk drive, and a printer.

INSTRUCTOR REFERENCES: Instructor Training Device Manual

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2.

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0000	INTRODUCTION Under instructor guidance, student practice of operator control actions on the CRT terminal using the keyboard, numerical key pad, and touch-activated screen, as demonstrated in Session 11.	
0001	STUDENT PRACTICE WITH TRAINER	Trainer Routine
0048	REVIEW SESSION	

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 13

SESSION TITLE: Computer Software Routines, Scheduled and Optimum Start/Stop

SESSION TIME: 50 minutes

SESSION TYPE: Lecture and Demonstration

OBJECTIVES: 1. Introduce students to computer software. 2. Explain how energy conservation routines work and save energy. 3. Demonstrate operator inputs and energy conserved.

INSTRUCTOR REFERENCES: EMCS Design Manual, Sections 3.5 - 3.7
Instructor Training Device Manual

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2, Sec. 3

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0000	INTRODUCTION	
	Description of hardware, software, and interaction between them	
	Describe and demonstrate software routines and how they save energy: scheduled start/stop, optimum start/stop.	
0001	DESCRIBE HARDWARE/SOFTWARE	
	Define hardware	
	Define software	
	Describe relationship between hardware and software in EMCS application	
	Discuss computer languages; FORTRAN, BASIC, PASCAL and assembly	
	Discuss design problems for unique HVAC systems	
	Of the nineteen routines to be presented, each EMCS will have some, but never all incorporated	
	The intent of the EMCS is to conserve energy	
0010	DEFINE SCHEDULED START/STOP	

SESSION TITLE: Computer Software Routines, Scheduled and Optimum Start/Stop

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0011	HOW ENERGY IS SAVED	
	HVAC operation not necessary during unoccupied periods	
	Ways energy is saved, with examples:	
	1. Auxiliary loads	
	2. Building cooling loads	
	3. Building heating loads	
	4. Ventilation cooling loads	
	5. Ventilation heating loads	
	Bulk of savings is auxiliary and ventilation heating energy	
0015	HOW SCHEDULED START/STOP WORKS	V13-1 SCHEDULED START/STOP
	Type equipment to which it is applied	
	EMCS sends on/off signals to a relay for each system	
	Start/Stop schedule programmed to track occupancy schedule	
	Warm up/cool down time	
	Early shutdown and flywheel effect	
0018	DEMONSTRATE OPERATOR INPUTS FOR SCHEDULED START/STOP	Trainer Routine: SCHEDULED START/STOP
0020	DEMONSTRATE ENERGY CONSERVATION	
0022	DEFINE OPTIMUM START/STOP	
0023	HOW ENERGY IS SAVED:	V13-2 OPTIMUM START/STOP
	Discussion follows that for scheduled start/stop, emphasizing differences	

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 13

SESSION TITLE: Computer Software Routines, Scheduled and Optimum Start/Stop

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0025	HOW OPTIMUM START/STOP WORKS	
	Type equipment to which it is applied	
	EMCS sends on/off signals to a relay for each system	
	Optimum start/stop based on occupancy schedule, target temperatures, weather conditions, equipment capability, and building characteristics	
	Makes optimum use of flywheel effect for greater energy savings	
0029	DEMONSTRATE OPERATOR INPUTS FOR OPTIMUM START/STOP	Trainer Routine: OPTIMUM START/STOP
0030	DEMONSTRATE ENERGY CONSERVATION	
0031	STEAM RADIATION EXAMPLE	V13-3 STEAM RADIATION
	Describe EMCS points Describe application of Scheduled Start/Stop Describe refinement with Optimum Start/Stop	
0034	ELECTRIC RADIATION EXAMPLE	V13-4 ELECTRIC RADIATION
0036	HOT WATER RADIATION EXAMPLE	V13-5 HOT WATER RADIATION
0038	STEAM UNIT HEATER EXAMPLE	V13-6 STEAM UNIT HEATER
0040	ELECTRIC UNIT HEATER EXAMPLE	V13-7 ELECTRIC UNIT HEATER
0042	HOT WATER UNIT HEATER EXAMPLE	V13-8 HOT WATER UNIT HEATER
0044	TWO PIPE FAN COIL EXAMPLE	V13-9 TWO PIPE FAN COIL
0046	FOUR PIPE FAN COIL EXAMPLE	V13-10 FOUR PIPE FAN COIL
0048	REVIEW SESSION	

SESSION TITLE: Duty Cycling, Demand Limiting, Day/Night Setback, and Lighting Control Software Routines

SESSION TIME: 50 minutes

SESSION TYPE: Lecture and Demonstration

OBJECTIVES: To describe: Duty cycling, demand limiting, day/night setback and lighting control software routines. To demonstrate how they work and how they save energy.

INSTRUCTOR REFERENCES: EMCS Design Manual, Sections 3.8-3.10 and 3.23
Instructor Training Device Manual

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch. 2, Sec. 3

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0000	INTRODUCTION	
	Describe and demonstrate software routines and how they save energy: duty cycling; demand limiting, day/night setback and lighting control.	
0001	DEFINE DUTY CYCLING	
0002	HOW ENERGY IS SAVED	
	Allowable temperature drift in comfort zone	
	HVAC equipment seldom pushed to design limits	
	Continuous HVAC operation not required	
	Energy savings results from turning off fans and pumps for short periods on a rotating basis	
0005	HOW DUTY CYCLING WORKS	V14-1 DUTY CYCLE SCHEDULE
	Type equipment to which it is applied	
	EMCS sends on/off signals to a relay in each system	
	Runs on top of start/stop	
	Off/on time ratio is a function of the season and HVAC equipment duty cycle limitations	
	Rotating schedule	

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 14

SESSION TITLE: Duty Cycling, Demand Limiting, Day/Night Setback, and Lighting Control Software Routines.

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0008	DEMONSTRATE OPERATOR INPUTS FOR DUTY CYCLING	Trainer Routine: DUTY CYCLING
0011	DEMONSTRATE ENERGY CONSERVATION	
0014	DEFINE DEMAND LIMITING	
0015	HOW ENERGY IS SAVED	
	Rate schedules determined by utility company based upon demand as well as total consumption	V14-2 DETERMINING PEAK DEMAND
	Define peak demand, sliding window, ratchet clause	V14-3 RATCHET CLAUSE IMPACT
	Program seeks to keep peak demand below some target level by shedding electrical loads	
	HVAC is a prime candidate for shedding	
0018	HOW DEMAND LIMITING WORKS	
	Type equipment to which it is applied	
	EMCS sends on/off signals to a relay for each piece of equipment	
	Demand prediction	
	Loads shed on some pre-established priority schedule	
	Run in conjunction with duty cycling and start/stop	
0021	DEMONSTRATE OPERATOR INPUTS FOR DEMAND LIMITING	Trainer Routine: DEMAND LIMITING
0024	DEMONSTRATE ENERGY CONSERVATION	
0027	DEFINE DAY/NIGHT SETBACK	V14-4 DAY/NIGHT SETBACK FOR HEATING
0028	HOW ENERGY IS SAVED	
	Temperature setpoints may be reset during unoccupied periods	
	Applied to HVAC systems having no auxiliary fans or pumps	

SESSION TITLE: Duty Cycling, Demand Limiting, Day/Night Setback, and Lighting Control Software Routines

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
	Primary savings through reduced heating energy consumption	
	Some ventilation control included	
0031	HOW DAY/NIGHT SETBACK WORKS	
	Type equipment to which it is applied	
	EMCS sends reset signals to temperature controllers and OA damper controllers	
	Tied to building occupancy schedule	
0034	DEMONSTRATE OPERATOR INPUTS FOR DAY/NIGHT SETBACK	Trainer Routine: DAY/NIGHT SETBACK
0037	DEMONSTRATE ENERGY CONSERVATION. Discuss energy savings.	
0040	DEFINE LIGHTING CONTROL	V14-5 LIGHTING CONTROL
0041	HOW ENERGY IS SAVED	
	Lighting consumes about 30% of building energy	
	Allows lights to be on only when and where necessary	
0043	HOW LIGHTING CONTROL WORKS	
	Applied to lighting systems, internal and external	
	Tied to building occupancy schedule	
	EMCS sends signals to relays for each controlled lighting zone	
	Override needed to overtime use of lighting	
	Maybe off only (manual on)	
0046	DIRECT FIRED FURNACE EXAMPLE	V14-6 DIRECT FIRED FURNACE
	Describe Day/Night Setback Operation	
0050	REVIEW SESSION	

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 15

SESSION TITLE: Economizer, Enthalpy, Ventilation and Recirculation Software Routines.

SESSION TIME: 50 minutes

SESSION TYPE: Lecture and Demonstration

OBJECTIVES: To describe: Economizer, Enthalpy, Ventilation and Recirculation Software routines. To demonstrate how they work and how they save energy.

INSTRUCTOR REFERENCES: EMCS Design Manual, Sections 3.11 - 3.13
Instructor Training Device Manual

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch. 2, Sec. 3

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0000	INTRODUCTION	
	Describe and demonstrate software routines, and how they save energy: economizer, enthalpy, and ventilation and recirculation.	
0002	DEFINE ECONOMIZER	
0003	HOW ENERGY IS SAVED	
	Need for year-round cooling - perimeter/interior zones - modern buildings with better envelopes	V15-1 DRY BULB ECONOMIZER CONTROL
	Sufficiently cool outside air may be used to aid mechanical refrigeration	
	Primary savings through reduced energy consumption cooling	V15-2 ECONOMIZER ENERGY SAVINGS
0006	HOW ECONOMIZER WORKS	
	Used with air handler units	
	EMCS sends control signals to position OA, EA and RA dampers Changeover temperature is a function of humidity	
	Savings varies by geographic area	
0010	DEMONSTRATE OPERATOR INPUTS FOR ECONOMIZER	Trainer Routine: ECONOMIZER
0013	DEMONSTRATE ENERGY CONSERVATION	

SESSION TITLE: Economizer, Enthalpy, Ventilation and Recirculation Software Routines

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0016	DEFINE ENTHALPY	
0017	HOW ENERGY IS SAVED	V15-3 ENTHALPY ECONOMIZER CONTROL
	Similar to economizer	
	Uses total heat (enthalpy)	
	How to determine enthalpy (H)	
	Economizer or enthalpy may be used, but not both	
	Primary savings through reduced cooling energy consumption	
0021	HOW ENTHALPY WORKS	V15-4 PSYCHROMETRIC CHART
	Define and discuss psychrometric chart	
	Used with air handlers	
	Measure OAT and humidity	
	Measure RAT and humidity	
	Compare OAH and RAH	
	EMCS sends control signals to position OA, EA and RA dampers	
	Savings compared to economizer	V15-5 ECONOMIZER/ENTHALPY COMPARISON
0025	DEMONSTRATE OPERATOR INPUTS FOR ENTHALPY	Trainer Routine: ENTHALPY
0029	DEMONSTRATE ENERGY CONSERVATION	
0032	DEFINE VENTILATION AND RECIRCULATION	
0034	HOW ENERGY IS SAVED	
	Operates in conjunction with economizer or enthalpy	
	Ventilation not needed when spaces are not occupied	
	Closes OA dampers during unoccupied periods	

SESSION TITLE: Economizer, Enthalpy, Ventilation and Recirculation Software Routines

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
	Savings results from reduced heating or cooling energy consumption	
0038	HOW VENTILATION AND RECIRCULATION WORKS	V15-6 VENTILATION AND RECIRCULATION
	Used with air handlers	
	Monitors OA damper position and OAT	
	Activated when OA would not impose additional thermal loads on the system	
	EMCS sends control signals to position OA dampers	
	Savings	
0041	DEMONSTRATE OPERATOR INPUTS FOR VENTILATION AND RECIRCULATION	Trainer Routine: VENTILATION AND RECIRCULATION
0042	DEMONSTRATE ENERGY CONSERVATION	
0043	SINGLE ZONE AHV EXAMPLE	V15-7 SINGLE ZONE AHU
	Describe EMCS points	
	Describe Economizer, Enthalpy, and Ventilation/Recirculation Programs operation	
0045	VARIABLE AIR VOLUME AHU EXAMPLE	V15-8 VARIABLE AIR VOLUME AHU
0047	SINGLE ZONE DX-AC UNIT EXAMPLE	V15-9 SZ DX UNIT
0050	SUMMARIZE SESSION	

SESSION TITLE: Hot Deck/Cold Deck Temperature Reset, Reheat Coil Reset, Boiler Optimization, Remote Boiler Monitoring and Hot Water Outside Air Reset Software Routines.

SESSION TIME: 50 minutes

SESSION TYPE: Lecture and Demonstration

OBJECTIVES: To describe hot deck/cold deck temperature reset, reheat coil reset, boiler optimization, remote boiler monitoring and hot water outside air reset. To demonstrate how they work and save energy.

INSTRUCTOR REFERENCES: EMCS Design Manual, Section 3.14 - 3.18
Instructor Training Device Manual

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2, Sec. 3

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0000	INTRODUCTION	
	Descriptions and demonstrations of hot deck/cold deck temperature reset, reheat coil reset, boiler optimization, hot remote boiler monitoring and hot water outside air reset software routines. Discussion of how they work and save energy.	
0001	DEFINE HOT DECK/COLD DECK TEMPERATURE RESET	
0002	HOW ENERGY IS SAVED	V16-1 HOT DECK/COLD DECK TEMPERATURE RESET
	Review dual duct, multizone design strategy and discuss inefficiency	
	Varied heating and cooling loads permit hot/cold deck resets	
	Least energy wasted when differential between hot deck and cold deck is the smallest	
0004	HOW HOT DECK/COLD DECK TEMPERATURE RESET WORKS	
	Monitors damper positions	
	Resets hot deck for greatest heating demand	
	Resets cold deck for greatest cooling demand	
	Humidity override	

SESSION TITLE: Hot Deck/Cold Deck Temperature Reset, Reheat Coil Reset, Boiler Optimization, and Hot Water Outside Air Reset Software Routines

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0007	DEMONSTRATE OPERATOR INPUTS FOR HOT DECK/COLD DECK TEMPERATURE RESET.	Trainer Routine: HOT DECK/COLD DECK TEMPERATURE RESET
0009	DEMONSTRATE ENERGY CONSERVATION	
0011	DEFINE REHEAT COIL RESET	
0012	HOW ENERGY IS SAVED	V16-2 TERMINAL REHEAT SYSTEM
	Terminal reheat system operates with constant cold deck discharge temperature	
	If every zone is reheating supply air, cold deck discharge temperature is too low	
	Cold deck discharge temperature is reset to greatest cooling demand	V16-3 COLD DECK TEMPERATURE RESET
	Savings through reduced cooling and reheating energy consumption	
0015	HOW REHEAT COIL RESET WORKS	
	Used on terminal reheat systems	
	Monitor cold deck discharge temperature and zone reheat coil valves	
	Cold deck discharge temperature reset upward until critical zone requires no rheat	
	Must account for humidity control limits	
0018	DEMONSTRATE OPERATOR INPUTS FOR REHEAT COIL RESET	Trainer Routine: REHEAT COIL RESET
0020	DEMONSTRATE ENERGY CONSERVATION	
0022	DEFINE BOILER OPTIMIZATION	
0023	HOW ENERGY IS SAVED	
	Most boilers achieve maximum efficiency only at rated output	
	In most cases boilers don't run at rated output (design conditions)	

SESSION TITLE: Hot Deck/Cold Deck Temerature Reset, Reheat Coil Reset, Boiler Optimization, Remote Boiler Monitoring and Hot Water Outside Air Reset Software Routines.

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
	Additional boilers are brought on line as heating load increases, keeping each on-line boiler fired at near capacity.	
	5-10% improvement in seasonal efficiency	
0026	HOW BOILER OPTIMIZATION WORKS	V16-4 HEATING LOAD DISTRIBUTION
	Used with hot water or steam boilers	
	Monitor all boilers to develop efficiency profiles	V16-5 BOILER CYCLING EFFICIENCY
	Select combination of boilers with greatest efficiency to given heating load	
	Boilers may be started manually or by the EMCS	
0029	DEFINE REMOTE BOILER MONITORING AND SUPERVISION	
0030	HOW ENERGY IS SAVED	V16-6 FLUE GAS ANALYSIS
	Fossil fuels are expensive	
	Boilers should be adjusted for maximum efficiency	
	Aids in boiler maintenance	
	Savings through reduced boiler-operator labor hours and reduced heating energy. Note that DoD or individual service criteria governs boiler operating practice and will affect potential labor savings.	
0033	HOW REMOTE BOILER MONITORING WORKS	
	Operates on steam or hot water boilers	
	Monitors all boilers as with boiler optimization	
	Keep boilers clean and adjusted for maximum efficiency	
0035	DEFINE HOT WATER OUTSIDE AIR RESET	

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 16

SESSION TITLE: Hot Deck/Cold Deck Temperature Reset, Reheat Coil Reset, Boiler Optimization, Remote Boiler Monitoring and Hot Water Outside Air Reset Software Routines.

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0036	HOW ENERGY IS SAVED	V16-7 HEAT LOSS FROM PIPES
	Hot water systems made to meet design requirements	
	Hot water supply temperature may be reduced, as OAT goes up and thereby reduces heating requirements	
	Lower differential temperature between air and supply water reduces losses	
	Savings is through reduced heating energy consumption	
0037	HOW HOT WATER OUTSIDE AIR RESET WORKS	V16-8 HOT WATER RESET SCHEDULE
	Works with hot water heating systems	
	Monitor OAT and hot water supply temperature	
	EMCS resets hot water supply temperature on a reset schedule	
	Reset schedule may need to be adjusted to suit local requirements.	
0040	TERMINAL REHEAT AHU EXAMPLE	V16-9 TERMINAL REHEAT AHU
	Discuss EMCS points	
	Discuss energy applications programs	
	MULTIZONE AHU EXAMPLE	V16-10 MULTIZONE AHU
	STEAM BOILER EXAMPLE	V16-11 STEAM BOILER
	HOT WATER BOILER EXAMPLE	V16-12 H.W. BOILER
	STEAM/HW CONVERTOR EXAMPLE	V16-13 STM/HW CONVERTOR
0048	REVIEW SESSION	

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 17

SESSION TITLE: Descriptions and Demonstrations of Chiller Optimization, Chilled Water Temperature Reset, Condenser Water Temperature Reset, and Chiller Demand Limit Software Routines.

SESSION TIME: 50 minutes

SESSION TYPE: Lecture and Demonstration

OBJECTIVES: To describe chiller optimization, chilled water temperature reset, condenser water temperature reset, and chiller demand limit software routines. To demonstrate how they work and how they save energy.

INSTRUCTOR REFERENCES: EMCS Design Manual, Sections 3.19 - 3.22
Instructor Training Device Manual

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2, Sec. 3

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0000	INTRODUCTION	
	Description and demonstration of chiller optimization, chilled water temperature reset, condenser water temperature reset, and chiller demand limit software routines. Discussion of how they work and save energy.	
0001	DEFINE CHILLER OPTIMIZATION	
0002	HOW ENERGY IS SAVED	
	Chillers work most efficiently at a particular load condition	V17-1 CHILLER EFFICIENCY
	Desirable to select optimium combination of chillers for each cooling load condition	V17-2 MULTIPLE CHILLERS
	Savings results from reduced cooling energy consumption	
	Must allow for chiller stabilization when coming on-line	
0005	HOW CHILLER OPTIMIZATION WORKS	V17-3 MULTIPLE CHILLER OPERATION
	Use manufacturer's data or collect data to determine chiller efficiency profiles	
	Program determines most efficient combination for given cooling load	

SESSION TITLE: Descriptions and Demonstrations of Chiller Optimization, Chilled Water Temperature Reset, Condenser Water Temperature Reset, and Chiller Demand Limit Software Routines

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
	Chillers may be started manually or by EMCS	
	EMCS sends start/stop signals to interposing relays for chiller, chilled water pump, condensate pump and cooling tower fan.	
0008	DEMONSTRATE OPERATOR INPUTS FOR CHILLER OPTIMIZATION	
0010	DEMONSTRATE ENERGY CONSERVATION	
0012	DEFINE CHILLED WATER TEMPERATURE RESET	
0013	HOW ENERGY IS SAVED	
	Chillers normally maintain a constant chilled water supply temperature for design conditions	
	In many cases chilled water supply temperature may be reset upward without loss of human comfort	
	Higher CSW temperature reduces chiller head pressure, which increases operating efficiency	V17-4 CHILLER HEAD PRESSURE VARIATION
	Savings is through reduced cooling energy consumption	
0016	HOW CHILLER WATER TEMPERATURE RESET WORKS	VL7-5 CHW TEMP. EFFECT ON COP
	Used on rotating or reciprocating refrigeration machines	
	Monitor zone CWS value positions space temperature and CWS temperature	
	CWS temperature is reset upward until the critical zone CWS value is fully open	
0018	DEMONSTRATE OPERATOR INPUTS FOR CHILLED WATER TEMPERATURE RESET	Trainer Routine: CHILLED WATER TEMPERATURE RESET
0021	DEMONSTRATE ENERGY CONSERVATION	
0024	DEFINE CONDENSER WATER TEMPERATURE RESET	
0025	HOW ENERGY IS SAVED	

SESSION TITLE: Descriptions and Demonstrations of Chiller Optimization, Chilled Water Temperature Reset, Condenser Water Temperature Reset, and Chiller Demand Limit Software Routines

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
	Heat rejection equipment is usually designed to maintain a constant condenser water temperature	V17-6 COND. WATER TEMP. ON COP
	Where ambient conditions will allow it, lower condenser water temperature will act to subcool the refrigerant	
	Lower condenser water temperature reduces chiller head pressure, which increased operating efficiency	
	Savings is through reduced cooling energy consumption	
0028	HOW CONDENSER WATER TEMPERATURE RESET WORKS	
	Used with water cooled chillers	
	Monitor outside wet bulb temperature and condenser water temperature	
	EMCS resets condenser water temperature control point according to manufacturer's specifications	
0030	DEMONSTRATE OPERATOR INPUTS FOR CONDENSER WATER TEMPERATURE RESET	Trainer Routine: CONDENSER WATER TEMPERATURE RESET
0032	DEMONSTRATE ENERGY CONSERVATION	
0033	DEFINE CHILLER DEMAND LIMIT	
0034	HOW ENERGY IS SAVED	
	Chillers cannot easily be turned on and off to limit demand	
	Chillers are normally adjustable for cooling capacity (load)	
	Chiller capacity can be reduced in steps to reduce total electric load	
	Savings results from keeping below peak demand level for facility	

SESSION TITLE: Descriptions and Demonstrations of Chiller Optimization, Chilled Water Temperature Reset, Condenser Water Temperature Reset, and Chiller Demand Limit Software Routines.

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0035	HOW CHILLER DEMAND LIMIT WORKS	V17-7 CHILLER DEMAND LIMIT
	Used with load adjustable chillers	
	Monitors chiller motor current	
	EMCS sends step control signals to chillers	
	Minimum chiller cooling capacity must be considered	
0040	AIR COOLED CHILLER EXAMPLE	V17-8 AIR COOLED CHILLER
0043	WATER COOLED CHILLER EXAMPLE	V17-9 WATER COOLED CHILLER
0045	OPERATOR INPUT FOR APPLICATIONS PROGRAMS	V17-10 EXAMPLE DATA LIST
	Discuss requirement for data definition by base operating personnel on initial system startup	
0047	DISCUSS SAFEGUARDING OF PROPRIETARY SOFTWARE	
0050	APPLICATIONS SOFTWARE SUMMARY	

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 18

SESSION TITLE: Laboratory II

SESSION TIME: 50 minutes

SESSION TYPE: Demonstration and Laboratory

OBJECTIVES: 1. For students to learn to call up an energy conservation routine.
2. For students to learn to explain and enter inputs required for operating conservation routines.

INSTRUCTOR REFERENCES: Instructor Training Device Manual

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2, Sec.3.

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0000	INTRODUCTION	
	Demonstration of and student practice with EMCS Operator Training Device calling up energy conservation routines, entering necessary parameters, and observing resultant energy savings.	
0001	DEMONSTRATE CALLING UP ENERGY CONSERVATION ROUTINE	Trainer Routines
	Demonstrate entering parameters	
	Demonstrate energy conservation	
0004	STUDENT PRACTICE WITH TRAINER	
0048	REVIEW SESSION	

EMCS OPERATOR TRAINING COURSE
LESSON 5 - SESSION 23

SESSION TITLE: Laboratory III

SESSION TIME: 50 minutes

SESSION TYPE: Laboratory

OBJECTIVES: Student practice in: 1. Describing alarm conditions presented, 2. Diagnosing the cause of the alarm conditions, and 3. Entering the proper corrective commands on the operator terminal.

INSTRUCTOR REFERENCES: Instructor Training Device Manual

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.3, Sec. 2.

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0000	INTRODUCTION	
	Student practice with EMCS Operator Training Device in working with alarm conditions.	Trainer Routines
0001	STUDENT PRACTICE WITH TRAINER	
0048	REVIEW SESSION	

EMCS OPERATOR TRAINING COURSE
LESSON 5 - SESSION 24

SESSION TITLE: Laboratory IV	PAGE 1 OF 1
SESSION TIME: 50 minutes	SESSION TYPE: Laboratory

OBJECTIVES: Student practice in: 1. Describing alarm conditions presented, 2. Diagnosing the cause of the alarm conditions, and 3. Entering the proper corrective commands on the operator terminal.

INSTRUCTOR REFERENCES: Instructor Training Device Manual

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.3, Sec.2

TIME	LESSON OUTLINE	KEY POINTS/AID CUES
0000	INTRODUCTION	
	Student practice with EMCS Operator Training Device in working with trend logs and printing reports.	Trainer Routines
0001	STUDENT PRACTICE WITH TRAINER	
0048	REVIEW SESSION	

CLASS NOTES

EMCS OPERATOR TRAINING COURSE LESSON 3 - SESSION 9	
SESSION TITLE: Introduction to EMCS	
OBJECTIVES: 1. To describe what an EMCS is. 2. Explain the purpose of an EMCS. 3. Describe how the EMCS connects to and provides monitor and control of a HVAC system.	
STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2, Sec.1	
TOPIC	VIEWGRAPHS
INTRODUCTION	
DEFINE EMCS	V9-1 EMCS DEFINITION
DISCUSS BACKGROUND AND EVOLUTIONARY PROCESS	

CLASS NOTES

EMCS OPERATOR TRAINING COURSE LESSON 3 - SESSION 9	
SESSION TITLE: Introduction to EMCS	
TOPIC	**VIEWGRAPHS**
EXPLAIN PURPOSE OF EMCS	
DESCRIBE HOW EMCS CONNECTS TO HVAC SYSTEMS	V9-2 POINTS DEFINITION V9-3 TWO PIPE FAN COIL V9-4 SINGLE ZONE AHU
DESCRIBE SYMBOLS AND ABBREVIATIONS FROM DESIGN MANUAL	V9-5 SYMBOLS AND ABBREVIATIONS
DISCUSS MONITOR AND CONTROL TECHNIQUES AS APPLIED THROUGH EMCS	V9-6 EMCS/HVAC LINK V9-7 MULTIZONE AHU V9-8 HOT WATER BOILER

EMCS OPERATOR TRAINING COURSE
LESSON 3 - SESSION 9

SESSION TITLE: Introduction to EMCS

TOPIC	VIEWGRAPHS
REVIEW SESSION	

EMCS OPERATOR TRAINING COURSE
LESSON 3 - SESSION 10

SESSION TITLE: EMCS Design

OBJECTIVES: 1. Describe the architecture of EMCS systems. 2. Identify each component of an EMCS. 3. Explain what each component does.

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2, Sec.2

TOPIC	VIEWGRAPHS
INTRODUCTION	
DEFINE CLASSIFICATIONS OF EMCS SYSTEMS	V10-1 EMCS SIZE CLASSIFICATION
DESCRIBE FUNCTIONS OF MAJOR COMPONENTS OF TYPICAL MICRO EMCS CONFIGURATION	V10-2 MICRO EMCS ARCHITECTURE

CLASS NOTES

EMCS OPERATOR TRAINING COURSE
LESSON 3 - SESSION 10

SESSION TITLE: EMCS Design

TOPIC	VIEWGRAPHS
DESCRIBE FUNCTIONS OF ADDITIONAL MAJOR COMPONENTS OF TYPICAL SMALL EMCS CONFIGURATION	V10-3 SMALL EMCS ARCHITECTURE
DESCRIBE FUNCTIONS OF ADDITIONAL MAJOR COMPONENTS OF TYPICAL MEDIUM EMCS CONFIGURATION	V10-4 MEDIUM EMCS ARCHITECTURE

CLASS NOTES

EMCS OPERATOR TRAINING COURSE
LESSON 3 - SESSION 10

SESSION TITLE: EMCS Design

TOPIC	VIEWGRAPHS
DESCRIBE FUNCTIONS OF ADDITIONAL MAJOR COMPONENTS OF TYPICAL LARGE EMCS CONFIGURATION	V10-5 LARGE EMCS ARCHITECTURE
REVIEW SESSION	

CLASS NOTES

EMCS OPERATOR TRAINING COURSE
LESSON 3 - SESSION 11

SESSION TITLE: Operator Interaction with EMCS

OBJECTIVES: Introduce students to various operator interactions with training device.

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2, Sec.2

TOPIC	VIEWGRAPHS
INTRODUCTION	V11-1 INTERFACE TYPES
COMMAND LANGUAGE INTERFACE	Trainer Routine INTERFACE TYPES
COMMAND LINE MNEMONIC	

EMCS OPERATOR TRAINING COURSE
LESSON 3 - SESSION 11

SESSION TITLE: Operator Interaction with EMCS

TOPIC	VIEWGRAPHS
MENU PENETRATION	
INTERACTIVE COLOR GRAPHICS	
DEMONSTRATE DISK DRIVE OPERATION	
DISCUSS SOME OTHER OPERATOR FUNCTIONS	V11-2 ADDITIONAL OPERATOR FUNCTIONS

CLASS NOTES

EMCS OPERATOR TRAINING COURSE LESSON 3 - SESSION 12	
SESSION TITLE: Laboratory 1	Page 1 of 1
OBJECTIVES: 1. For students to become familiar with the various types of operator interfaces using the EMCS Operator Training Device; operation of the CRT computer terminal using keyboard, numeric key pad, and touch screen, operation of a floppy disk drive and a printer.	
STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2	
TOPIC	VIEWGRAPHS
INTRODUCTION	
STUDENT PRACTICE WITH TRAINER	Trainer Routine
REVIEW SESSION	

CLASS NOTES

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 13

SESSION TITLE: Computer Software Routines, Scheduled and Optimum Start/Stop

OBJECTIVES: 1. Introduce students to computer software. 2. Explain how energy conservation routines work and save energy. 3. Demonstrate operator inputs and energy conserved.

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2, Sec.3

TOPIC	VIEWGRAPHS
INTRODUCTION	
DESCRIBE HARDWARE/SOFTWARE	
DEFINE SCHEDULED START/STOP	

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 13

SESSION TITLE: Computer Routines, Scheduled and Optimum Start/Stop

TOPIC	VIEWGRAPHS
HOW ENERGY IS SAVED	
HOW SCHEDULED START/STOP WORKS	V13-1 SCHEDULED START/STOP

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 13

SESSION TITLE: Computer Software Routines, Scheduled and Optimum Start/Stop

TOPIC	VIEWGRAPHS
DEMONSTRATE OPERATOR INPUTS FOR SCHEDULED START/STOP	Trainer Routine: SCHEDULED START/STOP
DEMONSTRATE ENERGY CONSERVATION	
DEFINE OPTIMUM START/STOP	
HOW ENERGY IS SAVED:	V13-2 OPTIMUM START/STOP

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 13

SESSION TITLE: Computer Software Routines, Scheduled and Optimum Start/Stop

TOPIC	VIEWGRAPHS
HOW OPTIMUM STRAT/STOP WORKS	
DEMONSTRATE OPERATOR INPUTS FOR OPTIMUM START/STOP	Trainer Routine: OPTIMUM START/STOP
DEMONSTRATE ENERGY CONSERVATION	

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 13

SESSION TITLE: Computer Software Routines, Scheduled and Optimum Start/Stop

TOPIC	VIEWGRAPHS
STEAM RADIATION EXAMPLE	V13-3 STEAM RADIATION
ELECTRIC RADIATION EXAMPLE	V13-4 ELECTRIC RADIATION
HOT WATER RADIATION EXAMPLE	V13-5 HOT WATER RADIATION

CLASS NOTES

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 13

SESSION TITLE: Computer Software Routines, Scheduled and Optimum Start/Stop

TOPIC	VIEWGRAPHS
STEAM UNIT HEATER EXAMPLE	V13-6 STEAM UNIT HEATER
ELECTRIC UNIT HEATER EXAMPLE	V13-7 ELECTRIC UNIT HEATER
HOT WATER UNIT HEATER EXAMPLE	V13-8 HOT WATER UNIT HEATER
TWO PIPE FAN COIL EXAMPLE	V13-9 TWO PIPE FAN COIL

EMCS OPERATOR TRAINING COURSE LESSON 4 - SESSION 13	
SESSION TITLE: Computer Software Routines, Scheduled and Optimum Start/Stop	Page 7 of 7
TOPIC	VIEWGRAPHS
FOUR PIPE FAN COIL EXAMPLE	V13-10 FOUR PIPE FAN COIL
REVIEW SESSION	

CLASS NOTES

EMCS OPERATOR TRAINING COURSE

LESSON 4 - SESSION 14

SESSION TITLE: Duty Cycling, Demand Limiting, Day/Night Setback, and Lighting Control Software Routines

OBJECTIVES: To describe: Duty cycling, demand limiting, day/night setback and lighting control software routines. To demonstrate how they work and how they save energy.

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2, Sec.3

TOPIC	VIEWGRAPHS
INTRODUCTION	
DEFINE DUTY CYCLING	
HOW ENERGY IS SAVED	

CLASS NOTES

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 14

SESSION TITLE: Duty Cycling, Demand Limiting, Day/Night Setback, and Lighting Control Software Routines

TOPIC	VIEWGRAPHS
HOW DUTY CYCLING WORKS	V14-1 DUTY CYCLE SCHEDULE
DEMONSTRATE OPERATOR INPUTS FOR DUTY CYCLING	Trainer Routine: DUTY CYCLING
DEMONSTRATE ENERGY CONSERVATION	

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 14

SESSION TITLE: Duty Cycling, Demand Limiting, Day/Night Setback, and Lighting Control Software Routines

TOPIC	VIEWGRAPHS
DEFINE DEMAND LIGHTING	
HOW ENERGY IS SAVED	V14-2 DETERMINING PEAK DEMAND V14-3 RATCHET CLAUSE IMPACT
HOW DEMAND LIMITING WORKS	

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 14

SESSION TITLE: Duty Cycling, Demand Limiting, Day/Night Setback, and Lighting Control Software Routines

TOPIC	VIEWGRAPHS
DEMONSTRATE OPERATOR INPUTS FOR DEMAND LIMITING	Trainer Routine: DEMAND LIMITING
DEMONSTRATE ENERGY CONSERVATION	
DEFINE DAY/NIGHT SETBACK	V14-4 DAY/NIGHT SETBACK FOR HEATING

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 14

SESSION TITLE: Duty Cycling, Demand Limiting, Day/Night Setback, and Lighting Control Software Routines

TOPIC	VIEWGRAPHS
HOW ENERGY IS SAVED	
HOW DAY/NIGHT SETBACK WORKS	

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 14

SESSION TITLE: Duty Cycling, Demand Limiting, Day/Night Setback, and Lighting Control Software Routines

TOPIC	VIEWGRAPHS
DEMONSTRATE OPERATOR INPUTS FOR DAY/NIGHT SETBACK	Trainer Routine: DAY/NIGHT SETBACK
DEMONSTRATE ENERGY CONSERVATION	
DEFINE LIGHTING CONTROL	V14-5 LIGHTING CONTROL
HOW ENERGY IS SAVED	

SESSION TITLE: Duty Cycling, Demand Limiting, Day/Night Setback, and Lighting Control Software Routines

TOPIC	VIEWGRAPHS
HOW LIGHTING CONTROL WORKS	
DEFINE FIRED FURNACE EXAMPLE	V14-6 DIRECT FIRED FURNACE
REVIEW SESSION	

CLASS NOTES

EMCS OPERATOR TRAINING COURSE

LESSON 4 - SESSION 15

SESSION TITLE: Economizer, Enthalpy, Ventilation and Recirculation Software Routines

OBJECTIVES: To describe: Economizer, Enthalpy, Ventilation and Recirculation Software Routines. To demonstrate how they work and how they save energy.

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2, Sec.3

TOPIC	VIEWGRAPHS
INTRODUCTION	
DEFINE ECONOMIZER	
HOW ENERGY IS SAVED	V15-1 DRY BULB ECONOMIZER CONTROL V15-2 ECONOMIZER ENERGY SAVINGS

CLASS NOTES

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 15

SESSION TITLE: Economizer, Enthalpy, Ventilation and Recirculation Software Routines

TOPIC	VIEWGRAPHS
HOW ECONOMIZER WORKS	
DEMONSTRATE OPERATOR INPUTS FOR ECONOMIZER	Trainer Routine: ECONOMIZER
DEMONSTRATE ENERGY CONSERVATION	
DEFINE ENTHALPY	

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 15

SESSION TITLE: Economizer, Enthalpy, Ventilation and Recirculation Software Routines

TOPIC	VIEWGRAPHS
HOW ENERGY IS SAVED	V15-3 ENTHALPY ECONOMIZER CONTROL
HOW ENTHALPY WORKS	V15-4 PSYCHROMETRIC CHART V15-5 ECONOMIZER/ENTHALPY COMPARISON
DEMONSTRATE OPERATOR INPUTS FOR ENTHALPY	Trainer Routine: ENTHALPY

EMCS OPERATOR TRAINING COURSE LESSON 4 - SESSION 15	
SESSION TITLE: Economizer, Enthalpy, Ventilation and Recirculation Software Routines	Page 4 of 6

TOPIC	VIEWGRAPHS
DEMONSTRATE ENERGY CONSERVATION	
DEFINE VENTILATION AND RECIRCULATION	
HOW ENERGY IS SAVED	
HOW VENTILATION AND RECIRCULATION WORKS	V15-6 VENTILATION AND RECIRCULATION

CLASS NOTES

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 15

SESSION TITLE: Economizer, Enthalpy, Ventilation and Recirculation Software Routines

TOPIC	VIEWGRAPHS
DEMONSTRATE OPERATOR INPUTS FOR VENTILATION AND RECIRCULATION	Trainer Routine: VENTILATION AND RECIRCULATION
DEMONSTRATE ENERGY CONSERCATION	
SINGLE ZONE AHU EXAMPLE	V15-7 SINGLE ZONE AHU

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 15

SESSION TITLE: Economizer, Enthalpy, Ventilation and Recirculation Software Routines

TOPIC	VIEWGRAPHS
VARIABLE AIR VOLUME AHU EXAMPLE	V15-8 VARIABLE AIR VOLUME AHU
SINGLE ZONE DX-AC UNIT EXAMPLE	V15-9 SZ DX UNIT
SUMMARIZE SESSION	

CLASS NOTES

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 16

SESSION TITLE: Hot Deck/Cold Deck Temperature Reset, Reheat Coil Reset, Boiler Optimization, Remote Boiler Monitoring and Hot Water Outside Air Reset Software Routines

OBJECTIVES: To describe: Hot deck/cold deck temperature reset, reheat coil reset, boiler optimization, rèmote boiler monitoring and hot water outside air reset. To demonstrate how they work and save energy.

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2, Sec.3

TOPIC	VIEWGRAPHS
INTRODUCTION	
DEFINE HOT DECK/COLD DECK TEMPERATURE RESET	
HOW ENERGY IS SAVED	V16-1 HOT DECK/COLD DECK TEMPERATURE RESET

SESSION TITLE: Hot Deck/Cold Deck Temperature Reset, Reheat Coil Reset, Boiler Optimization, Remote Boiler Monitoring and Hot Water Outside Air Reset Software Routines

TOPIC	VIEWGRAPHS
HOW HOT DECK/COLD DECK TEMPERATURE RESET WORKS	
DEMONSTRATE OPERATOR INPUTS FOR HOT DECK/COLD DECK TEMPERATURE RESET	Trainer Routine: HOT DECK/COLD DECK TEMPERATURE RESET
DEMONSTRATE ENERGY CONSERVATION	
DEFINE REHEAT COIL RESET	

SESSION TITLE: Hot Deck/Cold Deck Temperature Reset, Reheat Coil Reset, Boiler Optimization, Remote Boiler Monitoring and Hot Water Outside Air Reset Software Routines

TOPIC	VIEWGRAPHS
HOW ENERGY IS SAVED	V16-2 TERMINAL REHEAT SYSTEM V16-3 COLD DECK TEMPERATURE RESET
HOW REHEAT COIL RESET WORKS	

CLASS NOTES

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<tr><td>DEMONSTRATE OPERATOR INPUTS FOR REHEAT COIL RESET

DEMONSTRATE ENERGY CONSERVATION

DEFINE BOILER OPTIMIZATION

HOW ENERGY IS SAVED</td><td>Trainer Routine:
REHEAT COIL RESET</td></tr>
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SESSION TITLE: Hot Deck/Cold Deck Temperature Reset, Reheat Coil Reset, Boiler Optimization, Remote Boiler Monitoring and Hot Water Outside Air Reset Software Routines

TOPIC	VIEWGRAPHS
HOW BOILER OPTIMIZATION WORKS	V16-4 HEATING LOAD DISTRIBUTION V16-5 BOILER CYCLING EFFICIENCY
DEFINE REMOTE BOILER MONITORING AND SUPERVISION	
HOW ENERGY IS SAVED	V16-6 FLUE GAS ANALYSIS

CLASS NOTES

SESSION TITLE: Hot Deck/Cold Deck Temperature Reset, Reheat Coil Reset, Boiler Optimization, Remote Boiler Monitoring and Hot Water Outside Air Reset Software Routines

TOPIC	VIEWGRAPHS
HOW REMOTE BOILER MONITORING WORKS	
DEFINE HOT WATER OUTSIDE AIR RESET	
HOW ENERGY IS SAVED	V16-7 HEAT LOSS FROM PIPES

SESSION TITLE: Hot Deck/Cold Deck Temperature Reset, Reheat Coil Reset, Boiler Optimization, Remote Boiler Monitoring and Hot Water Outside Air Reset Software Routines

TOPIC	VIEWGRAPHS
HOW HOT WATER OUTSIDE AIR RESET WORKS	V16-8 HOT WATER RESET SCHEDULE
TERMINAL REHEAT AHU EXAMPLE	V16-9 TERMINAL REHEAT AHU
MULTIZONE AHU EXAMPLE	V16-10 MULTIZONE AHU

CLASS NOTES

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 16

SESSION TITLE: Hot Deck/Cold Deck Temperature Reset, Reheat Coil Reset, Boiler Optimization, Remote Boiler Monitoring and Hot Water Outside Air Reset Software Routines

TOPIC	VIEWGRAPHS
STEAM BOILER EXAMPLE	V16-11 STEAM BOILER
HOT WATER BOILER EXAMPLE	V16-12 HOT WATER BOILER
STEAM/HW CONVERTOR EXAMPLE	V16-13 STEAM/HW CONVERTOR
REVIEW SESSION	

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 17

SESSION TITLE: Descriptions and Demonstrations of Chiller Optimization, Chilled Water Temperature Reset, Condenser Water Temperature Reset, and Chiller Demand Limit Software Routines

OBJECTIVES: To describe chiller optimization, chilled water temperature reset, condenser water temperature reset, and chiller demand limit software routines. To demonstrate how they work and how they save energy.

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2, Sec.3

TOPIC	VIEWGRAPHS
INTRODUCTION	
DEFINE CHILLER OPTIMIZATION	
HOW ENERGY IS SAVED	V17-1 CHILLER EFFICIENCY V17-2 MULTIPLE CHILLERS

CLASS NOTES

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 17

SESSION TITLE: Descriptions and Demonstrations of Chiller Optimization, Chilled Water Temperature Reset, Condenser Water Temperature Reset, and Chiller Demand Limit Software Routines

TOPIC	VIEWGRAPHS
HOW CHILLER OPTIMIZATION WORKS	V17-3 MULTIPLE CHILLER OPERATION
DEMONSTRATE OPERATOR INPUTS FOR CHILLER OPTIMIZATION	
DEMONSTRATE ENERGY CONSERVATION	
DEFINE CHILLED WATER TEMPERATURE RESET	

SESSION TITLE: Descriptions and Demonstrations of Chiller Optimization, Chilled Water Temperature Reset, Condenser Water Temperature Reset, and Chiller Demand Limit Software Routines

TOPIC	VIEWGRAPHS
HOW ENERGY IS SAVED	V17-4 CHILLER HEAD PRESSURE VARIATION
HOW CHILLER WATER TEMPERATURE RESET WORKS	V17-5 CHILLER WATER TEMPERATURE EFFECT ON COP

CLASS NOTES

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 17

SESSION TITLE: Descriptions and Demonstrations of Chiller Optimization, Chilled Water Temperature Reset, Condenser Water Temperature Reset, and Chiller Demand Limit Software Routines

TOPIC	VIEWGRAPHS
DEMONSTRATE OPERATOR INPUTS FOR CHILLED WATER TEMPERATURE RESET	Trainer Routine; CHILLED WATER TEMPERATURE RESET
DEMONSTRATE ENERGY CONSERVATION	
DEFINE CONDENSER WATER TEMPERATURE RESET	
HOW ENERGY IS SAVED	V17-6 CONDENSED WATER TEMPERATURE ON COP

SESSION TITLE: Descriptions and Demonstrations of Chiller Optimization, Chilled Water Temperature Reset, Condenser Water Temperature Reset, and Chiller Demand Limit Software Routines

TOPIC	VIEWGRAPHS
HOW CONDENSER WATER TEMPERATURE RESET WORKS	
DEMONSTRATE OPERATOR INPUTS FOR CONDENSER WATER TEMPERATURE RESET	Trainer Routine: CONDENSER WATER TEMPERATURE RESET
DEMONSTRATE ENERGY CONSERVATION	

SESSION TITLE: Descriptions and Demonstrations of Chiller Optimization, Chilled Water Temperature Reset, Condenser Water Temperature Reset, and Chiller Demand Limit Software Routines

TOPIC	VIEWGRAPHS
DEFINE CHILLER DEMAND LIMIT	
HOW ENERGY IS SAVED	
HOW CHILLER DEMAND LIMIT WORKS	V17-7 CHILLER DEMAND LIMIT

SESSION TITLE: Descriptions and Demonstrations of Chiller Optimization, Chilled Water Temperature Reset, Condenser Water Temperature Reset, and Chiller Demand Limit Software Routines

TOPIC	VIEWGRAPHS
AIR COOLED CHILLER EXAMPLE	V17-8 AIR COOLED CHILLER
WATER COOLED CHILLER EXAMPLE	V17-9 WATER COOLED CHILLER
OPERATOR INPUT FOR APPLICATIONS PROGRAMS	V17-10 EXAMPLE DATA LIST

CLASS NOTES

EMCS OPERATOR TRAINING COURSE LESSON 4 - SESSION 17	
SESSION TITLE: Descriptions and Demonstrations of Chiller Optimization, Chilled Water Temperature Reset, Condenser Water Temperature Reset, and Chiller Demand Limit Software Routines	

TOPIC	VIEWGRAPHS
DISCUSS SAFEGUARDING OF PROPRIETARY SOFTWARE	
APPLICATIONS SOFTWARE SUMMARY	

CLASS NOTES

EMCS OPERATOR TRAINING COURSE
LESSON 4 - SESSION 18

SESSION TITLE: Laboratory II

OBJECTIVES: 1. For students to learn to call up an energy conservation routine.
2. For students to learn to explain and enter inputs required for operating conservation routines.

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.2, Sec.3

TOPIC	VIEWGRAPHS
INTRODUCTION	
DEMONSTRATE CALLING UP ENERGY CONSERVATION ROUTINE	Trainer Routines
STUDENT PRACTICE WITH TRAINER	
REVIEW SESSION	

CLASS NOTES

EMCS OPERATOR TRAINING COURSE

LESSON 5 - SESSION 23

SESSION TITLE: Laboratory III

OBJECTIVES: Student practice in: 1. Describing alarm conditions presented, 2. Diagnosing the cause of the alarm conditions, and 3. Entering the proper corrective commands on the operator terminal.

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.3, Sec.2

TOPIC	VIEWGRAPHS
INTRODUCTION	Trainer Routines
STUDENT PRACTICE WITH TRAINER	
REVIEW SESSION	

CLASS NOTES
EMCS OPERATOR TRAINING COURSE
LESSON 5 - SESSION 24

SESSION TITLE: Laboratory IV

OBJECTIVES: Student Practice in: 1. Describing alarm conditions presented, 2. Diagnosing the cause of the alarm conditions, and 3. Entering the proper corrective commands on the operator terminal.

STUDENT REFERENCES AND HOMEWORK: EMCS Operator Training Manual, Ch.3, Sec.2

TOPIC	VIEWGRAPHS
INTRODUCTION	Trainer Routines
STUDENT PRACTICE WITH TRAINER	
REVIEW SESSION	